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# A PALYNOSTRATIGRAPHY OF THE BERRIASIAN TO BARREMIAN OF THE SPEETON CLAY OF SPEETON, ENGLAND

BY

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With 15 Plates and 21 Figures in the text and on 1 folder

**Abstract**

Dinoflagellate cysts from the type section of the Speeton Clay of East Yorkshire, England have been examined. These were taken from thirty-three samples covering the range Late Berriasian to Middle Barremian. Eighty-four taxa are recognised with twenty of these previously undescribed, including five new genera and eighteen new species. Four recombinations of species are carried out. The observed stratigraphical distribution of taxa is summarised on a range chart and the ranges of selected species are compared with those reported by previous authors. The studied section is divided into six units, based on inception and extinction of key taxa.

Key words:
Dinoflagellata — Palynostratigraphy — Cretaceous — England.

**Contents**



## I. Introduction

The Speeton Clay, together with the lower part of the Red Chalk, is important in being the most complete single section of the Early Cretaceous in northwest Europe. The deposit is thin (about 300 feet near Speeton) but all Stages of the Early Cretaceous are represented. It comprises a group of light to very dark limestones, marls and clays with a coastal exposure near Speeton between Boulder Clay and Kimmeridge Clay to the north and Chalk to the south. It was PHILLIPS in 1829 who first termed this group of rocks "Speeton Clay" and he applied the name to all blue clay between the Chalk and the Corallian in Filey Bay (see Text-fig. 1). It was later shown, however, that the lower part of PHILLIP's section is Kimmeridgian in age so that the term "Speeton Clay" is now applied only to the upper (Cretaceous) part. The Speeton Clay rests unconformably on Kimmeridge Clay (this unconformity is marked by the Coprolite Bed — Bed E of Lamplugh) and passes upwards apparently conformably into the Red Chalk.

On the whole, the Speeton Clay is a soft and easily disturbed deposit and the coastal exposure is much distorted by minor faults and folds caused by Chalk overburden and Pleistocene ice-drag. Study of the section

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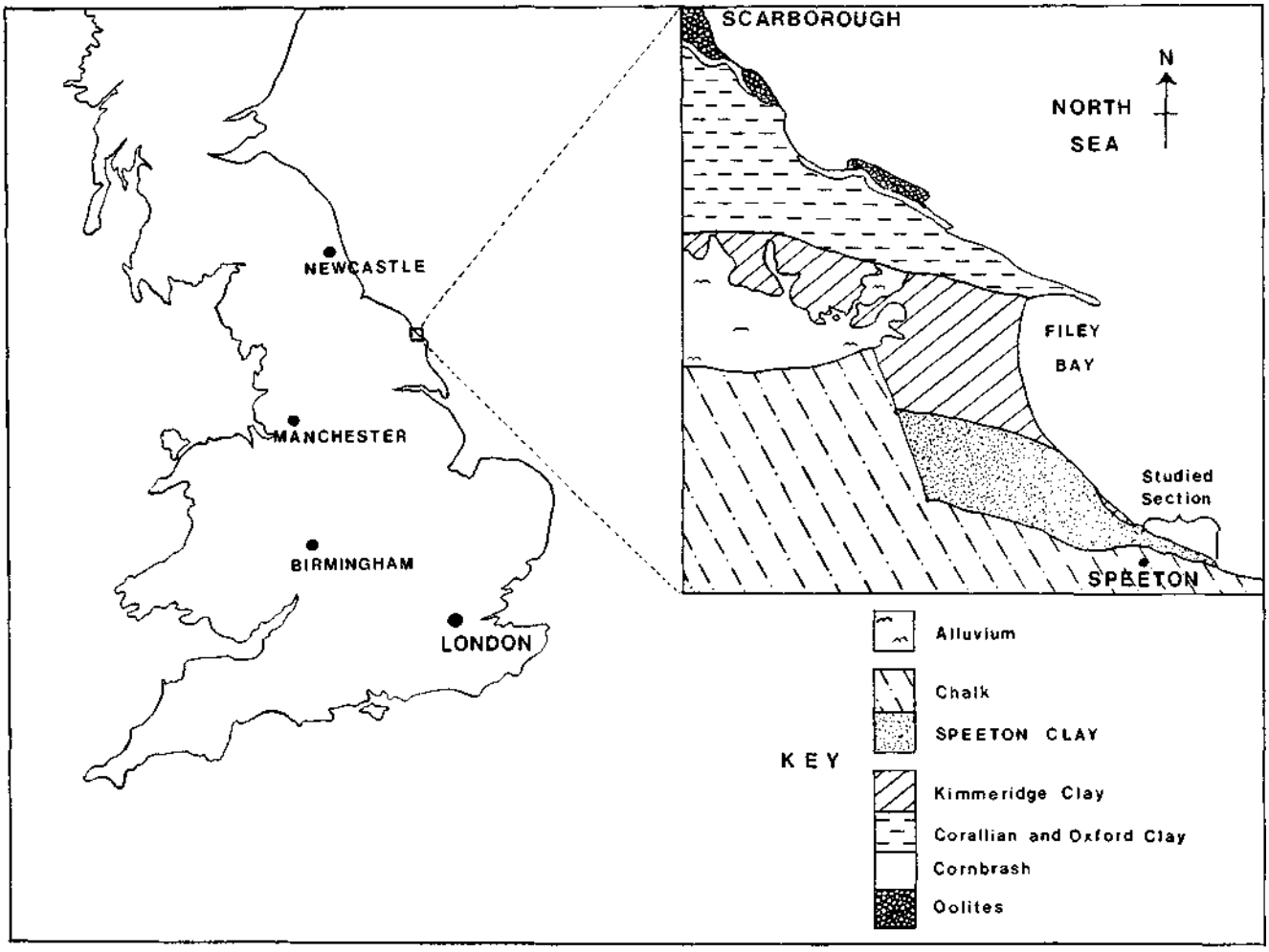
depends, therefore, on familiarity with the deposit in the field. Consequently, for the present work, the help of Dr. J. W. NEALE of the University of Hull was accepted gratefully in the collection of samples.

The Speeton Clay cliff near Speeton is divided into three discrete parts by spurs. These are termed (from north to south) New Closes Cliff, Middle Cliff and Black Cliff, with the main exposure being in the last two. Due to the distortion of the deposits, the thickness of the Speeton Clay has been variously estimated. These estimations vary from the 550 feet of JUDD (1868) to the 300 feet of LAMPLUGH (1889). In 1960, the Shell Speeton No. 1 borehole indicated that the true thickness is about 290 feet.

The first subdivisions of the Speeton Clay were attempted in LECKENBY 1859 and JUDD 1868. JUDD's subdivision was based on the ammonite fauna. It is true that ammonites are abundant at Speeton, but only in limited horizons with much of the clay containing none or only crushed specimens. Consequently, the generally employed subdivision is that of LAMPLUGH (1889) which is based on the commonest of all fossils at Speeton, the belemnites. Employing these, he divided the clay into five parts, using the initials A to E in descending order with E being the oldest unit. The A Beds are characterised by *Belemnites minimus (Neohibolites minimus)* and are of Albian age. The B Beds are characterised by *Belemnites semicanaliculatus*? *(Oxyteuthis brunsvicensis)* and are of Late Hauterivian, Barremian and basal Aptian age. These beds were separated by LAMPLUGH into




Text-fig. 1. The location of the studied section (scale of blow-up — 1 inch ≡ 1.6 miles).

three major divisions, Upper B (UB), Middle B (MB) and Lower B (LB). The C Beds are characterised by *Belemnites jaculum (Hibolites jaculoides)* and are of Hauterivian age and the D Beds are characterised by *Belemnites lateralis (Acroteuthis lateralis)* and are Berriasian, Valanginian and basal Hauterivian in age. There is little overlap of the belemnite Zones. The bed E is a 4 inch thick "Coprolite Bed" consisting of a pyritised

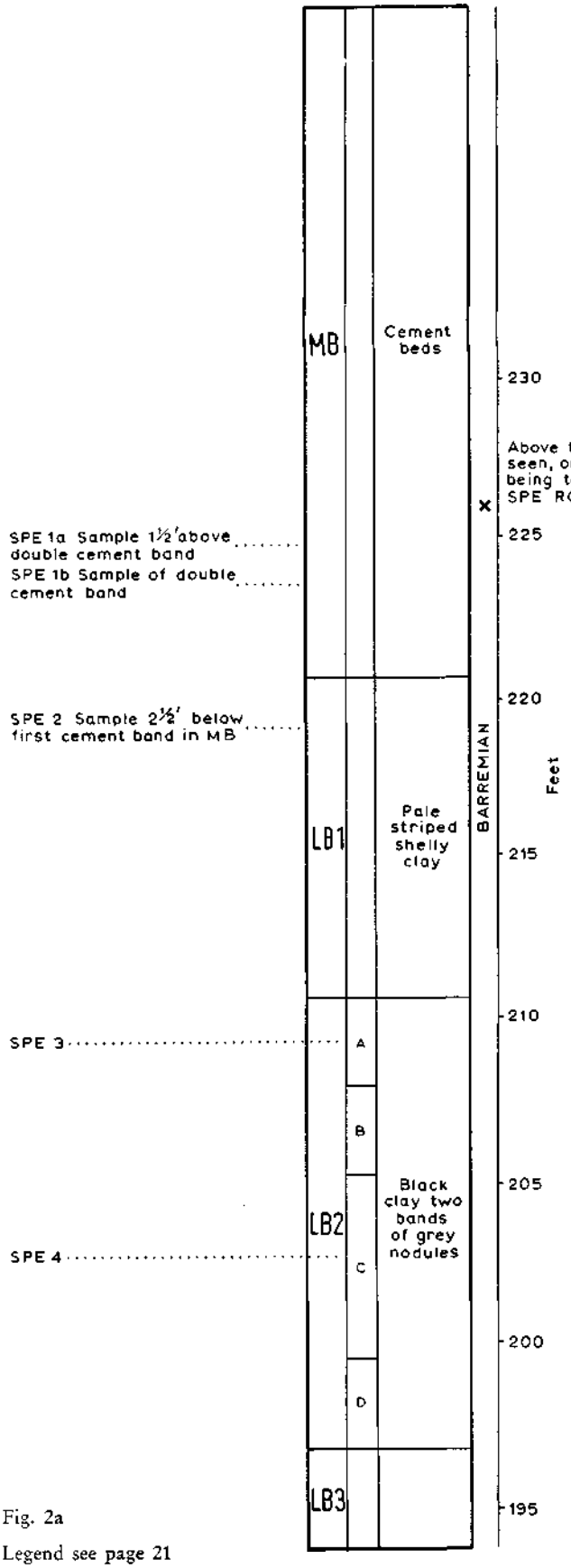



Fig. 2a

Legend see page 21

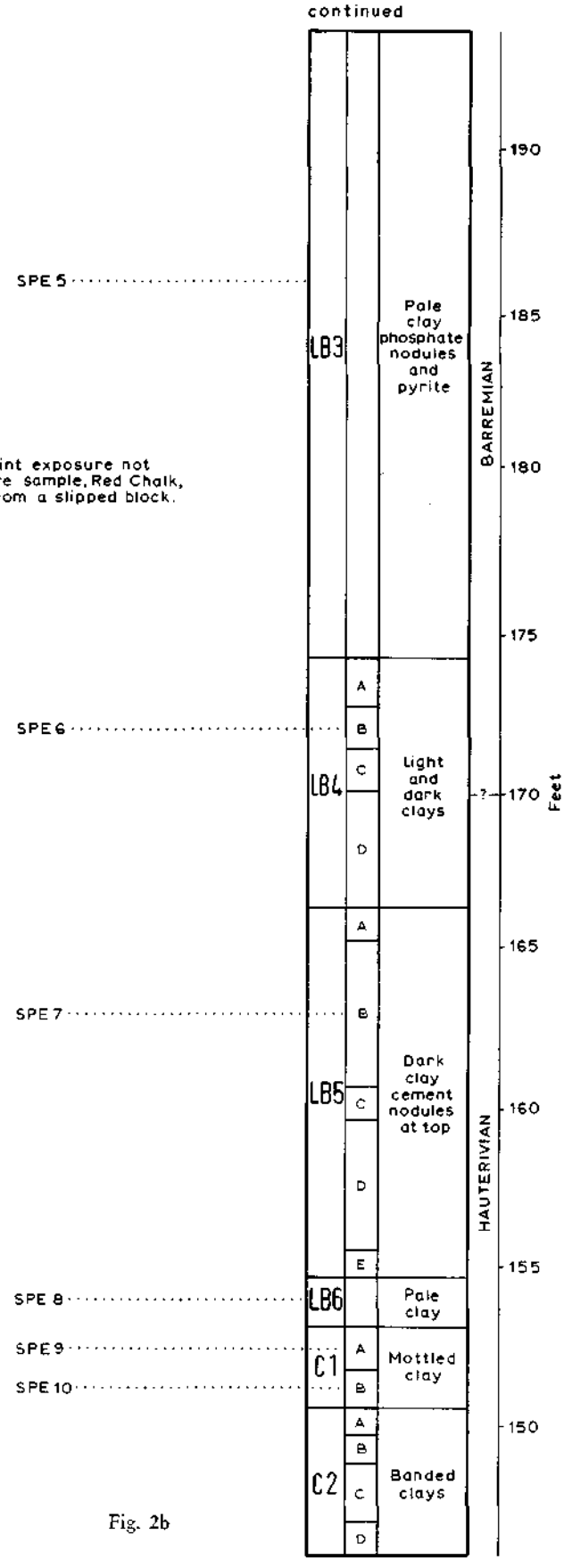



Fig. 2b

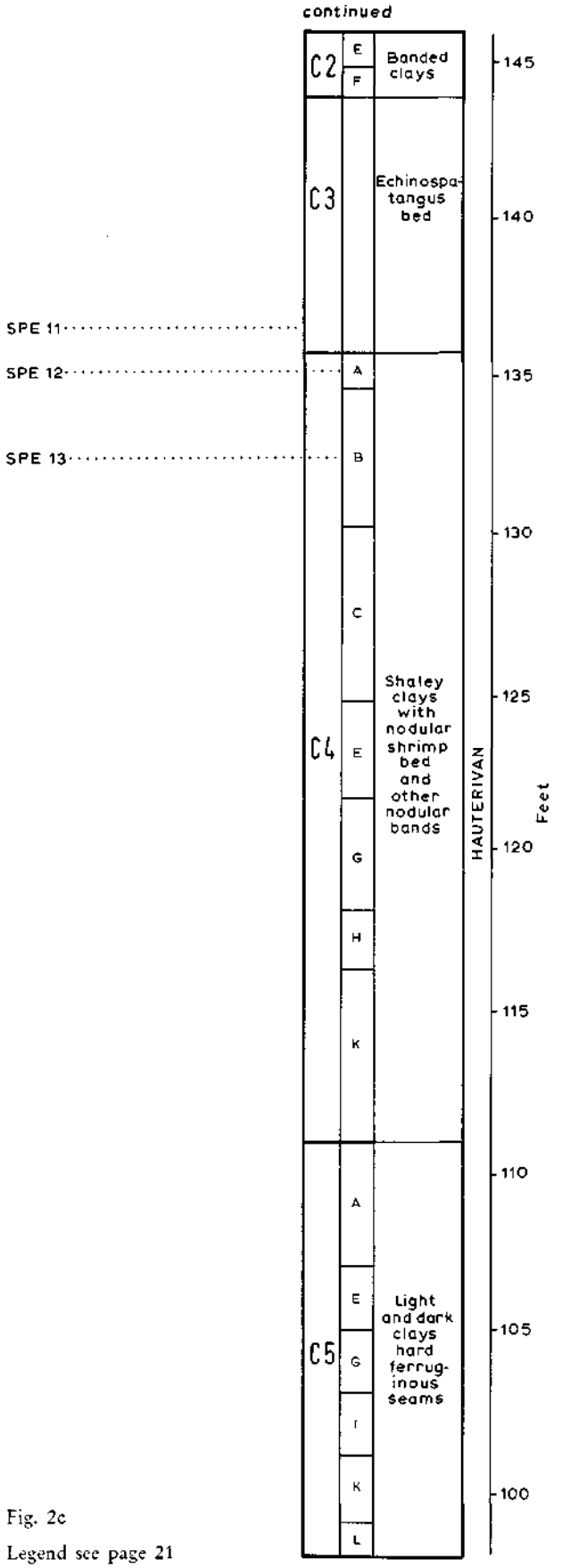



Fig. 2c

Legend see page 21

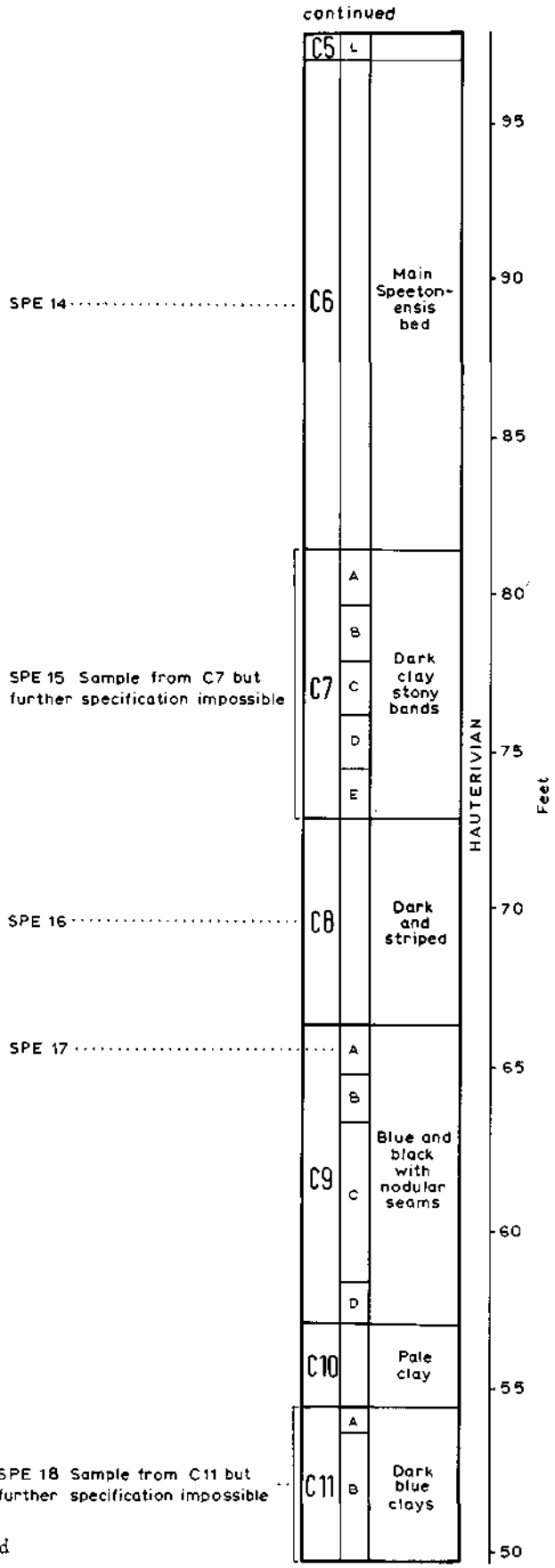
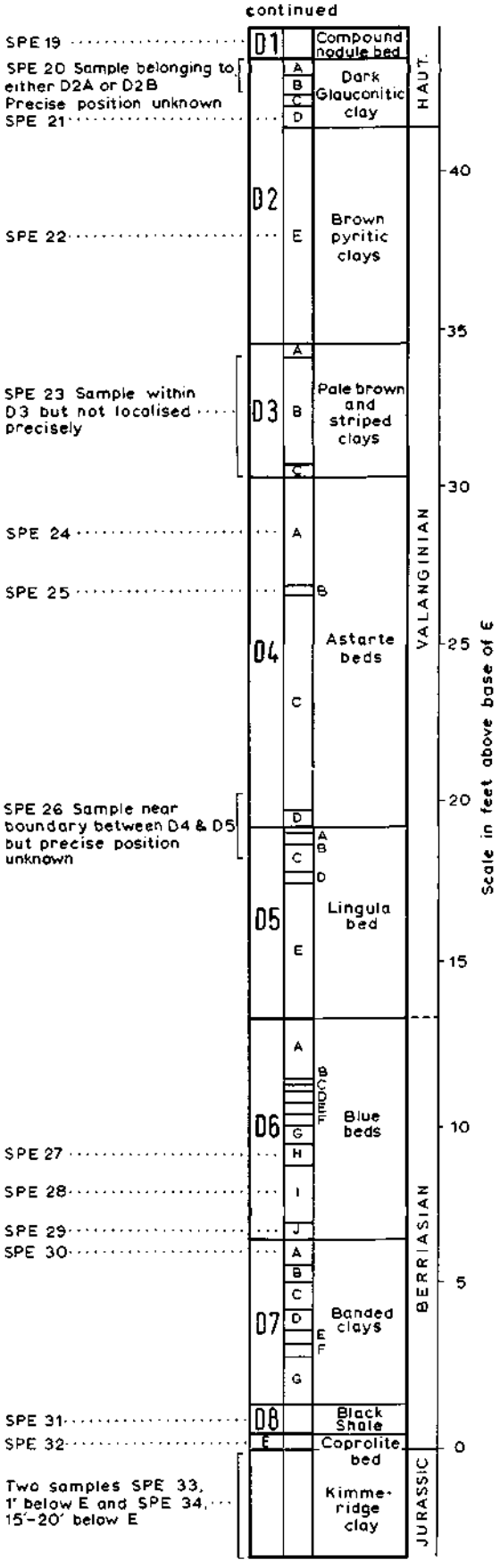



Fig. 2d




## SPECIMENS TAKEN FROM THE SPEETON CLAY, SPEETON, YORKS

All specimens taken from the beach exposure between Reighton Gap and Speeton Beck

Identification of beds in the field by Dr J W Neale, University of Hull

REFERENCES FOR SECTION

D and E beds - Neale J W; Speeton Clay D beds E. Yorks. Proc. Yorks. Geol. Soc. 36 1968

B and C beds - Fletcher B N; the distribution of Lower Cretaceous (Berriasian-Barremian) foraminifera in the Speeton Clay of Yorkshire England. In 'the Boreal Lower Cretaceous' Geol. Journal Special Issue No. 5 December 1973

Fig. 2e

Text-fig. 2. Specimens taken from the Speeton Clay, Speeton, Yorks.

and phosphatised band of nodules and stones marking the unconformity between the Speeton Clay and the Kimmeridge Clay below. CASEY (1973) has erected a zonation of beds spanning the Jurassic-Cretaceous boundary in the Spilsby Sandstone and correlated strata in eastern England, based on the ammonite fauna. He has divided the Berriasian of eastern England into eight ammonite Zones and he concludes that only the topmost of these Zones (that of *Peregrinoceras albidum)* may be recognised in the lowest few metres of the Speeton Clay. He maintains that it is unlikely that the Coprolite Bed of Speeton is older than the Mid-Spilsby nodule bed, which is of Late Ryazanian age (equivalent to the higher part of the Late Berriasian). The interval studied in the present work therefore ranges in age from the higher part of the Late Berriasian to the lower part of the Middle Barremian.

The lithological units recognisable within each of the A to E divisions of LAMPLUGH were numbered (i. e. A1, A2, UB1, UB2, etc.). In all, LAMPLUGH's subdivision of the Speeton Clay resulted in 33 units. These have subsequently been further divided, notably by KAYE (1964), who subdivided the B Beds, by FLETCHER (1969), who subdivided the C Beds and by NEALE (1960 & 1962), who subdivided the D Beds. Each of these authors used letters after LAMPLUGH's lithological units to indicate further subdivision (i. e. D2A, D2B, etc.). The result of all this is the production of a very fine resolution of the Speeton Clay into well over a hundred recognisable units.

The present work embodies a study of thirty-three samples taken from that part of the Speeton Clay ranging in age from Late Berriasian to Middle Barremian. The stratigraphical section (Text-fig. 2) indicates the samples collected from the Speeton Clay by the author. The sample of Red Chalk, which was taken from a slipped block, was examined and found to be completely barren of any acid-resistant material. No further reference is made to this sample in the present work. The two Kimmeridge Clay samples indicated in Text-fig. 2 are not dealt with in the present work since the inclusion of only two Late Jurassic samples (unconformable below the Cretaceous) in a work devoted otherwise exclusively to the Early Cretaceous was considered undesirable.

Eighty-four taxa are described here and their observed stratigraphical ranges are included in Text-fig. 21. Of these eighty-four, twenty are considered as being previously undescribed. These include five new genera and eighteen new species.

## II. Acknowledgements

The author would like to thank Prof. CHARLES DOWNIE of the Geology Department, University of Sheffield for his advice and encouragement in the initial stages of the present work. Thanks are also due to Dr. ROGER DAVEY of the Institute of Geological Sciences, Leeds whose suggestions and good natured criticisms have helped considerably. The author is indebted to The British Petroleum Company Limited for permission to publish and particularly to Drs. W. J. CLARKE and G. L. EATON for their constant help and interest.

## III. Systematic Descriptions

Species described in the present work are divided into three major groups — Gonyaulacacean Group, Peridiniacean Group and Unknown Affinities Group. This follows the procedure adopted by DAVEY & VERDIER (1971, 1973 & 1974) and by DAVEY (1974). The species in each group are listed in alphabetical order.

In the "Observed Dimensions" sections below, measurements recorded as x(y)z refer to x, the greatest observed, z, the smallest observed and y, the average of all observed values for any single dimension.

### Gonyaulacacean Group

### Genus *Achomosphaera* EVITT, 1963

*Achomosphaera neptuni* (EISENACK 1958) DAVEY & WILLIAMS 1966a.

(pl. 13, fig. 4)

1958 *Baltisphaeridium neptuni* EISENACK, p. 399, pl. 26, figs. 7, 8, text-fig. 8.
1966a *Achomosphaera neptuni* — DAVEY & WILLIAMS, p. 51, pl. 3, fig. 7, pl. 9, fig. 11.

Observed Dimensions: Main Body 64(52)44 x 55(45)36μ.
Processes (max.) 33(23)17μ.
Specimens Measured — 20.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Hauterivian to Aptian.

Genus *Adnatosphaeridium* Williams & Downie 1966

*Adnatosphaeridium apiculatum* (Cookson & Eisenack 1960b) Lentin & Williams 1973

(pl. 10, fig. 1)

1960b *Cannosphaeropsis apiculata* Cookson & Eisenack, p. 254, pl. 39, fig. 15.
1973 *Adnatosphaeridium apiculatum* — Lentin & Williams, p. 11.

Observed Dimensions: Overall 106(94)77 x 100(83)66μ.
Specimens Measured — 12.
Observed Range: Berriasian.
Previously Reported Range: "Probably Tithonian".

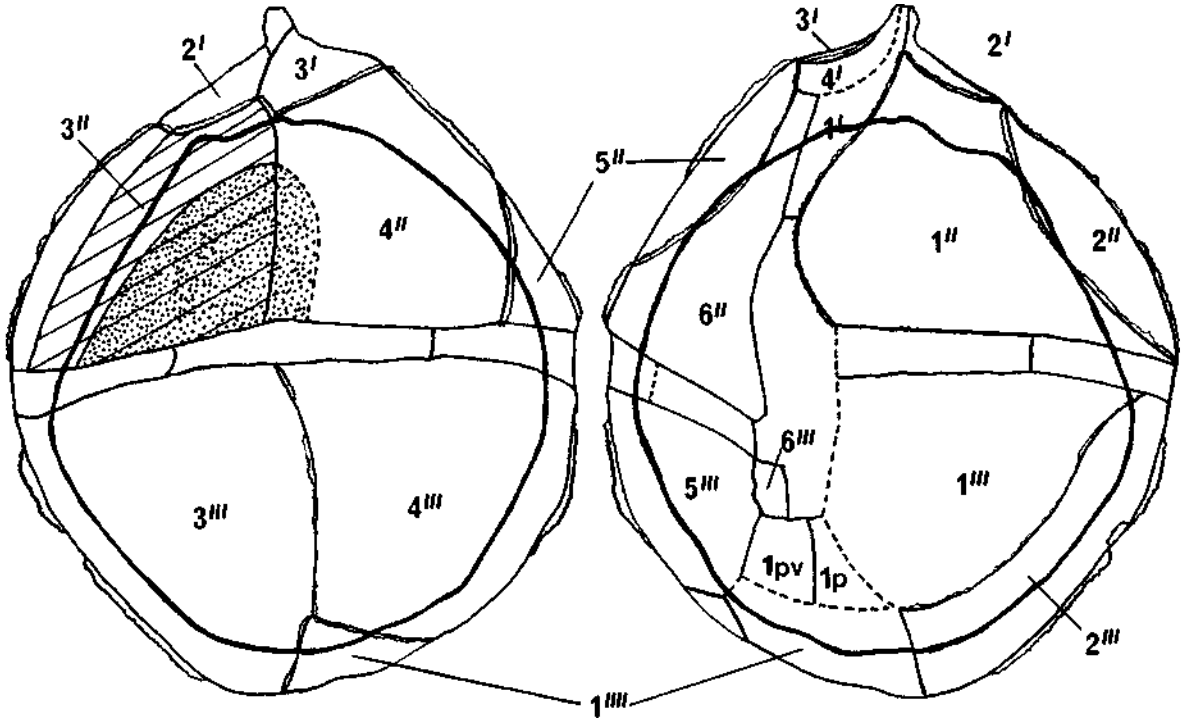
Genus *Athigmatocysta* n. gen.

Derivation of Name: From the Greek *a-*, not, and *thigma,* touch — with reference to its characteristic separation of body layers.

Diagnosis: Proximo-cavate cysts, spheroidal to ellipsoidal with no apparent contact between the two body layers. Tabulation ?4′, 6″, 6c, 6‴, 1p, 1pv, 1⁗, defined by poorly to well-developed sutural crests which are distinctly denticulate. A short apical horn is present. Archeopyle precingular, formed by loss of plate 3″.

Type Species: *Athigmatocysta glabra* n. sp.

Remarks: This genus resembles both *Gonyaulacysta* Deflandre 1964 emend. Sarjeant 1969 and *Psaligonyaulax* Sarjeant 1966a, differing from both in the cavation between the two body layers. All observed




Text-fig. 3. Camera lucida drawings of *Athigmatocysta glabra* n. gen. et sp., holotype. x 1250.

specimens of *Athigmatocysta glabra* n. sp. appeared to possess complete cavation between the endophragm and periphragm. Some connection between the two body layers is obviously necessary to maintain the position of the inner cyst within the periblast. Unfortunately, no such connection was observed here. *Gonyaulacysta* may possess an apical or antapical pericoel, but not both, and both *Gonyaulacysta* and *Psaligonyaulax* have a broad zone of contact between the body layers in the cingular area.

*Athigmatocysta* is distinguished from *Scriniodinium* KLEMENT 1957 in possessing a full tabulation and from *Endoscrinium* KLEMENT 1960 emend. VOZZHENNIKOVA 1967 in having six postcingular plates and a plate 1″″. *Endoscrinium* has only five postcingular plates and does not possess any antapical plates.

### *Athigmatocysta glabra* n. sp.

(pl. 11, figs. 1, 6, text-fig. 3)

Derivation of Name: From the Latin *glabra*, hairless, bald, smooth — with reference to the smooth body layers.
Holotype: Pl. 11, figs. 1, 6, text-fig. 3.
Type Locality: Division C11, Speeton Clay, Speeton, England.

Diagnosis: A thin-walled, distinctly bi-layered proximo-cavate cyst. The tabulation ?4′, 6″, 6c, 6‴, 1p, 1pv, 1⁗ is outlined on the periphragm by distinctly denticulate sutural crests of variable height. The endophragm is ellipsoidal, slightly longer than broad and produced into a low apical prominence which reflects the short apical horn borne by the periphragm. Both periphragm and endophragm are smooth. Archeopyle precingular, formed by loss of plate 3″.

Observed Dimensions: Holotype 94 x 79$\mu$.
Range 94(83)69 x 71(70)61$\mu$.
Specimens Measured — 11.

Observed Range: Berriasian to Barremian.

Remarks: This is a thin-walled form and is usually distorted. In better preserved specimens, there is apparently complete cavation between the endophragm and periphragm. Obviously there must be some connection between the body layers in order to maintain the position of the endoblast within the periblast. Unfortunately, no such connection was apparent here. The endophragm commonly exhibits an archeopyle reflecting that in the periphragm formed by loss of plate 3″. It is much less angular than 3″.

## Genus *Avellodinium* n. gen.

Derivation of Name: From the Latin *avello*, to tear away, separate — with reference to the removal of the epitract in archeopyle formation.

Diagnosis: Chorate cysts, ellipsoidal, bearing numerous, slender gonal processes, which are proximally connected along body sutures by low crests. Distally, the processes trifurcate, subsequently bifurcating once or twice. Cingulum laevo-rotatory, sulcus broad. Tabulation 3′, 6″, ?6c, 5‴, 1—2s, 1pv, 1⁗. Archeopyle epitractal.

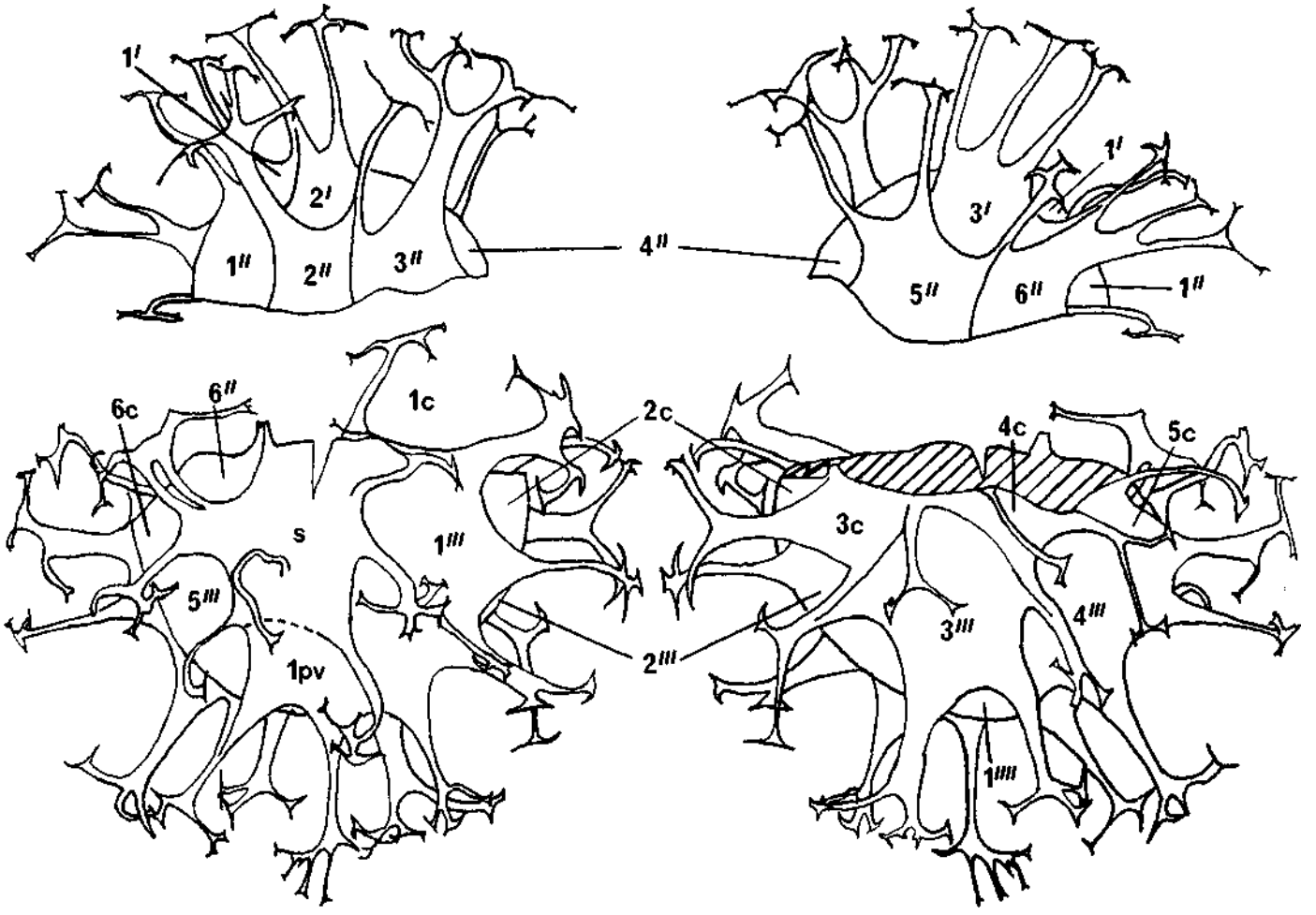
Type Species: *Avellodinium falsificum* n. sp.

Remarks: *Avellodinium* much resembles *Spiniferites* MANTELL 1850 emend. SARJEANT 1970, especially in the form of the processes. *Spiniferites* has, however, a precingular archeopyle which contrasts strongly with the epitractal archeopyle of *Avellodinium*. This epitractal archeopyle indicates that *Avellodinium* has some affinity with *Dichadogonyaulax* SARJEANT 1966a and *Ctenidodinium* (DEFLANDRE 1938) SARJEANT 1966a, two genera considered as synonymous in LENTIN & WILLIAMS 1973. *Avellodinium* differs from both in being obviously chorate (SARJEANT describes *Dichadogonyaulax* as proximate, as is *Ctenidodinium*), in possessing only gonal processes connected by low, unornamented crests and in the details of its tabulation.

### *Avellodinium falsificum* n. sp.

(pl. 5, figs. 1—3, text-fig. 4)

Derivation of Name: From the Latin *falsificus*, acting falsely. This refers to the superficial resemblance of this species to some species of *Spiniferites* MANTELL 1850 emend. SARJEANT 1970.




Text-fig. 4. Camera lucida drawings of *Avellodinium falsificum* n. gen. et sp. Hypotract drawn from the paratype (pl. 5, fig. 3). x 1750.

Holotype: Pl. 5, figs. 1, 2.
Type Locality: Division LB3, Speeton Clay, Speeton, England.

Diagnosis: A small, chorate cyst. The cyst body is ellipsoidal, smooth to finely granular and fairly thick-walled. The periphragm is closely connected to the endophragm except where it is produced into gonal processes and sutural crests. The processes are distally trifurcate, subsequently bifurcating once or twice to terminate in very slender, thread-like elements. Some cingular processes have a deep primary bifurcation. Tabulation 3', 6'', ?6c, 5''', 1pv, 1'''', outlined by low sutural crests. Sulcus broad, confined to hypotract. Archeopyle epitractal, cingulum laevo-rotatory.

Description: The endophragm is fairly thick and the periphragm is produced into gonal processes (no sutural processes were seen). These processes are usually proximally connected by low sutural crests. Occasionally, a few of the crests may be high and perforate.

The difference in level between the free ends of the cingulum causes the splitting off of part of plate 6'' during total removal of the epitract. Part of plate 6'' therefore remains attached to the hypotract. Specimens are often seen where some splitting has occurred but where plate 6'' is unbroken so that the two portions of the test remain attached.

Observed Dimensions: Holotype (complete) — Main Body 37 x 35$\mu$.
Overall 63 x 63$\mu$.
Complete Specimens — Main Body 41(35)23 x 44(33)28$\mu$.
Overall 70(63)53 x 68(59)46$\mu$.
Specimens Measured — 14.

Observed Range: Berriasian to Barremian.

Remarks: *Avellodinium falsificum* much resembles some species of *Spiniferites* MANTELL 1850 in overall morphology. It particularly resembles *Spiniferites ramosus* (EHRENBERG 1838) MANTELL 1854. However, the epitractal archeopyle in *Avellodinium falsificum* sets the two apart.

Genus *Callaiosphaeridium* DAVEY & WILLIAMS 1966

*Callaiosphaeridium asymmetricum* (DEFLANDRE & COURTEVILLE 1939) DAVEY & WILLIAMS 1966b

(pl. 10, fig. 10)

1939 *Hystrichosphaeridium asymmetricum* DEFLANDRE & COURTEVILLE, pp. 100, 101, pl. 4, fig. 1.
1966b *Callaiosphaeridium asymmetricum* — DAVEY & WILLIAMS, p. 104, pl. 8, figs. 9, 10, pl. 9, fig. 2.

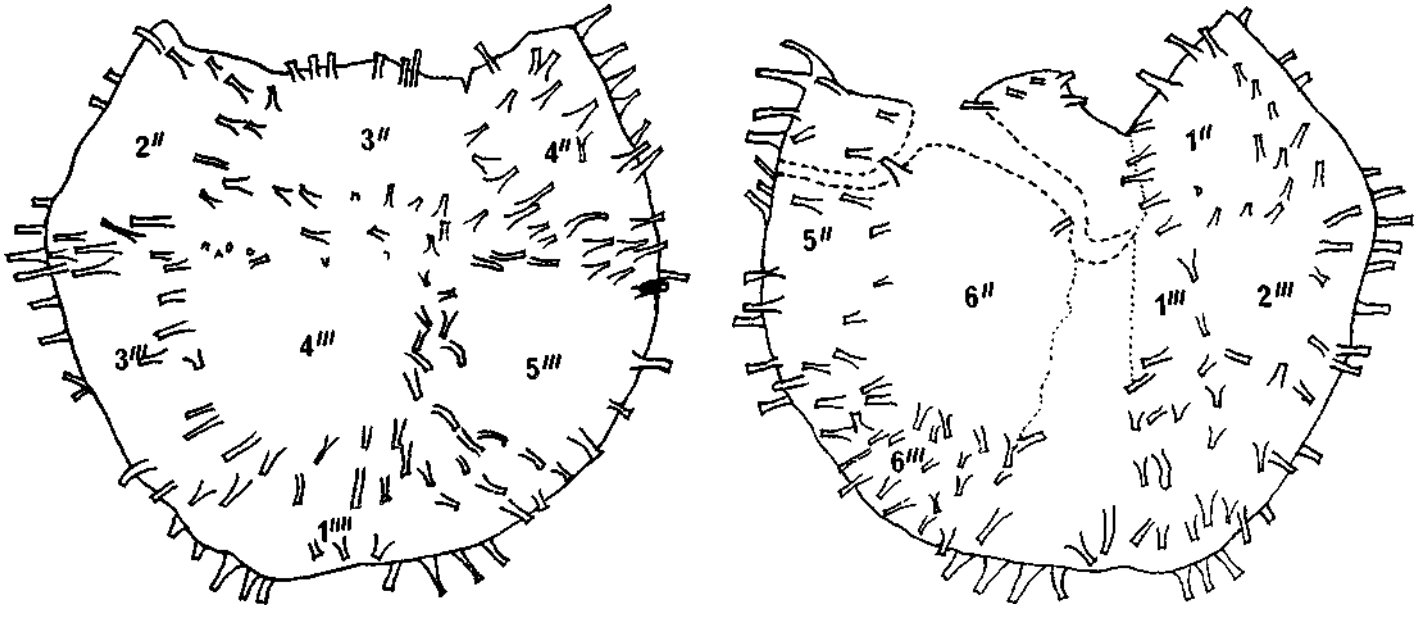
Observed Dimensions: Overall 83(77)72 x 81(73)69 µ.
Specimens Measured — 10.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian to Maastrichtian.

Genus *Canningia* COOKSON & EISENACK 1960

*Canningia* cf. *reticulata* COOKSON & EISENACK 1960b

(pl. 8, fig. 6, pl. 9, fig. 1)

Description: The specimens here described as *Canningia* cf. *reticulata* are dorso-ventrally flattened proximate cysts with a sub-circular outline. This outline is modified by a short, rounded apical prominence and by a distinct antapical indentation. The periphragm is completely reticulate and follows the form of the cyst body except at the antapex where it forms two distinct protruberances. The reticulum appears to be connected to the cyst body by numerous slender, short, intratabular spines. The cingulum is suggested in optical section where the periphragm is notched. Archeopyle apical with zig-zag margin.




Text-fig. 5. Camera lucida drawings of ? *Canninginopsis tabulata* (DAVEY & VERDIER 1974) n. comb. x 960.

Observed Dimensions: Complete Specimens — Overall 128(107)95 x 110(91)78μ.
Specimens Measured — 3.
Archeopyle Formed — Overall 111(81)73 x 108(90)66μ.
Specimens Measured — 15.
Observed Range: Hauterivian.

Remarks: This form closely resembles *Canningia reticulata* Cookson & Eisenack 1960b but differs in possessing a distinct apical projection and in having only a poorly defined cingulum. *C. reticulata* is described from "probably Tithonian" deposits whereas C. cf. *reticulata* is present only in the Hauterivian.

## Genus *Canninginopsis* Cookson & Eisenack 1962

### ? *Canninginopsis tabulata* (Davey & Verdier 1974) n. comb.

(pl. 8, figs. 3, 4, text-fig. 5)

1974 *Cyclonephelium tabulatum* Davey & Verdier, p. 630, pl. 92, figs. 1—4, pl. 93, fig. 6.

Observed Dimensions: Archeopyle Formed 81(75)68 x 95(82)76μ.
Specimens Measured — 5.
Observed Range: Barremian.
Previously Reported Range: Aptian.

Remarks: The species *Cyclonephelium tabulatum* is here transferred to ?*Canninginopsis tabulata*. The possession of large fields clearly outlined on the test precludes its inclusion in *Cyclonephelium*. The observed tabulation of ?*Canninginopsis tabulata* is 4′, 6″ 6‴, 1⁗ and is very similar both in formula and in its disposition on the test to that of *Canninginopsis denticulata* Cookson & Eisenack 1962, the type species of the genus.

## Genus *Cassiculosphaeridia* Davey 1969

### *Cassiculosphaeridia magna* Davey 1974

(pl. 11, fig. 8)

1974 *Cassiculosphaeridia magna* Davey, p. 46, pl. 1, figs. 3—7.

Observed Dimensions: Complete Specimens — Overall 121(105)88 x 100(94)88μ.
Specimens Measured — 3.
Archeopyle Formed — Overall 86(79)69 x 116(96)69μ.
Specimens Measured — 12.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Barremian.

## Genus *Cleistosphaeridium* Davey, Downie, Sarjeant & Williams 1966

### *Cleistosphaeridium polypes* (Cookson & Eisenack 1962) Davey 1969a

(pl. 11, fig. 3)

1962 *Hystrichosphaeridium recurvatum* subsp. *polypes* Cookson & Eisenack, p. 491, pl. 4, fig. 11.
1969a *Cleistosphaeridium polypes* Davey, p. 154, pl. 6, figs. 7, 8.

Observed Dimensions: Main Body 52(43)31 x 44(37)28μ.
Processes (max.) 19(17)13μ.
Specimens Measured — 11.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian to Cenomanian.

Genus *Coronifera* Cookson & Eisenack 1958

*Coronifera oceanica* Cookson & Eisenack 1958

(pl. 10, fig. 9)

1958 *Coronifera oceanica* Cookson & Eisenack, p. 45, pl. 12, figs. 5, 6.

Observed Dimensions: Overall 76(71)62 x 78(65)57$\mu$.
Specimens Measured — 11.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian to Santonian/Lowest Campanian.

Genus *Cribroperidinium* Neale & Sarjeant 1962 emend. Davey 1969

*Cribroperidinium edwardsi* (Cookson & Eisenack 1958) Davey 1969a

(pl. 3, fig. 6)

1958 *Gonyaulax edwardsi* Cookson & Eisenack, pp. 32, 33. pl. 3, fig. 6.
1969a *Cribroperidinium edwardsi* — Davey, p. 128.

Observed Dimensions: Overall 132(101)86 x 99(76)62$\mu$.
Specimens Measured — 31.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Berriasian to Oligocene (probably reworked).

*Cribroperidinium sepimentum* Neale & Sarjeant 1962

(pl. 2, fig. 1)

1962 *Cribroperidinium sepimentum* Neale & Sarjeant, pp. 443, 444, pl. 19, fig. 4.

Observed Dimensions: Overall 135(133)131 x 112(99)85$\mu$.
Specimens Measured — 3.
Observed Range: Hauterivian.
Previously Reported Range: Hauterivian to Aptian.
Remarks: Only three specimens were seen in the present study. It was also rare in the type material of Neale & Sarjeant.

Genus *Ctenidodinium* Deflandre 1938

*Ctenidodinium elegantulum* Millioud 1969

(pl. 9, figs. 7, 8)

1969 *Ctenidododinium elegantulum* Millioud, p. 427, pl. 2, figs. 1—3.

Observed Dimensions: Complete Specimens 88(86)83 x 88(84)79$\mu$.
Specimens Measured — 2.
Archeopyle Formed 66(55)44 x 84(69)51$\mu$.
Specimens Measured — 8.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Hauterivian and Barremian.

Genus *Cyclonephelium* Deflandre & Cookson 1955 emend. Williams & Downie 1966

*Cyclonephelium distinctum* Deflandre & Cookson 1955

(pl. 8, figs. 1, 2)

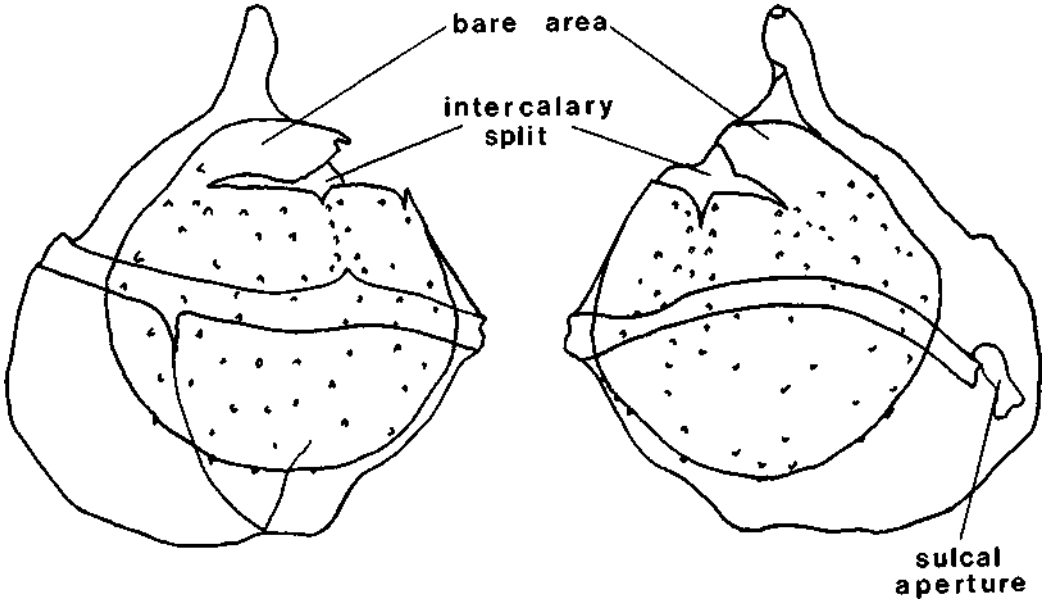
1955 *Cyclonephelium distinctum* Deflandre & Cookson, pp. 285, 286, pl. 2, fig. 14.

Observed Dimensions: Complete Specimens 105(79)65 x 99(75)57$\mu$.
Specimens Measured — 6.
Archeopyle Formed 92(72)57 x 99(80)61$\mu$.
Specimens Measured — 19.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Berriasian to Danian.

Genus *Dingodinium* Cookson & Eisenack 1958

*Dingodinium albertii* Sarjeant 1966b

(pl. 9, fig. 4, text-fig. 6)




Text-fig. 6. Camera lucida drawings of *Dingodinium albertii* Sarjeant 1966b. x 975.

1966b ?*Dingodinium albertii* Sarjeant, pp. 210, 211, pl. 21, fig. 3, pl. 23, fig. 1.

Observed Dimensions: Overall 79(66)51 x 72(54)43$\mu$.
Capsule 53(43)33 x 51(42)34$\mu$.
Apical Horn 29(17)8$\mu$.
Specimens Measured — 93.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Tithonian to Barremian.

Remarks: As pointed out by Davey (1974), this species possesses a definite apical archeopyle with the operculum rarely completely detached. A break occurs in the endophragm along a zig-zag line and in the periphragm along a much more irregular one. The operculum remains attached in the ventral area and is "hinged" with the rest of the cyst.

A previously undescribed feature of this form is the possession of a regular, relatively large hole in the periphragm in the sulcal region. Another apparently characteristic feature is the lack of ornament on the apical portion of the inner body. This last feature is clearly observed on the holotype (Sarjeant 1966b, pl. 21, fig. 3, pl. 23, fig. 1).

*Dingodinium albertii* is very similar to *Dingodinium cerviculum* Cookson & Eisenack 1958. The present author has examined specimens of *D. cerviculum* from Papua, New Guinea in order to be able to compare these two forms. The main difference between the two appears to be one of length (both inner body length and overall length). Dimensions of the studied specimens of *D. cerviculum* are: Overall 109(89)74 x 68(55)50$\mu$, inner body 58(52)46 x 47(42)36$\mu$, apical horn 39(23)17$\mu$; 31 specimens measured. In all respects other than

length, the two forms are almost identical. Because of this close similarity, *D. albertii* is here positively assigned to the genus *Dingodinium*. The discrepancy in length between *D. albertii* and *D. cerviculum* appears so marked that the two forms must be regarded as separate species.

*Parvocavatus tuberosus* GITMEZ 1970 is similar to *Dingodinium albertii*, differing in the possession of well-defined tabulation, in having ornament on the apical portion of the inner body, in having an inner body which almost fills the periphragm cavity and in having a cingulum whose ends are only slightly offset in the sulcal area. It is possible that the genus *Parvocavatus* should be transferred as a junior synonym to the genus *Dingodinium* (this would involve an emendation of the generic diagnosis of *Dingodinium* to include forms with a discernible tabulation).

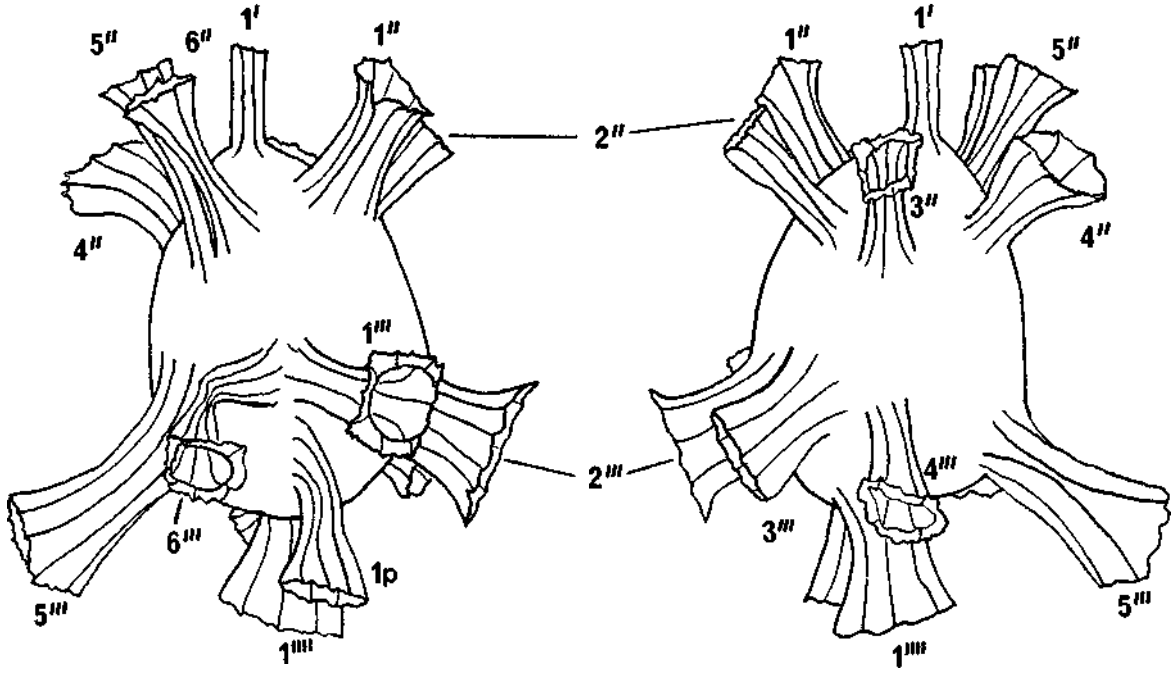
## Genus *Discorsia* n. gen.

Derivation of Name: From the Latin *discors*, different, unlike — in reference to the variable process size.

Diagnosis: Chorate cysts bearing 15 plate-centred, striate processes reflecting the tabulation 1′, 6″, 6‴, 1p, 1⁗. Main body ovoidal, epitract smaller and less rounded than hypotract. Processes variable in size; the apical process is small, the precingular processes somewhat larger and the postcingular and antapical processes are the largest of all. Archeopyle apical, formed by loss of plate 1′.

Type Species: *Discorsia nanna* (DAVEY 1974) n. comb., emend.

Remarks: In possessing a small number of plate-centred processes, *Discorsia* resembles *Oligosphaeridium* DAVEY & WILLIAMS 1966b. The various sizes of processes on each specimen and the single-plate apical archeopyle of *Discorsia* contrast with the approximately equal-sized processes and tetratabular archeopyle of *Oligosphaeridium*. *Discorsia* differs from *Cordosphaeridium* (EISENACK 1963) DAVEY 1969b in its apical archeopyle (*Cordosphaeridium* possesses a precingular one) and in the lack of any cingular processes. Also, the body surface of *Discorsia* is smooth to finely granular and bears no resemblance to the fibrous and pitted surface of *Cordosphaeridium*. *Discorsia* bears some resemblance to *Kleithriasphaeridium* DAVEY 1974. The main differences between the two are the archeopyle type (apical in *Discorsia* and precingular in *Kleithriasphaeridium*) and the number of processes, with *Kleithriasphaeridium* having 21—23 as opposed to the 15 of *Discorsia*. Also, *Discorsia nanna*, the type species of the genus, is considerably smaller than any described species of *Kleithriasphaeridium*.




Text-fig. 7. Camera lucida drawings of *Discorsia nanna* (DAVEY 1974) n. comb., indicating the reflected tabulation. x 1400.

*Discorsia nanna* (DAVEY 1974) n. comb., emend.

(pl. 10, fig. 8, text-fig. 7)

1974 *Oligosphaeridium nannum*, DAVEY, p. 59, pl. 4, figs. 9, 10.

Emended Diagnosis: A small chorate cyst. Endophragm smooth to finely granular, inner body ovoidal, longer than broad, with the epitract smaller and less rounded than the hypotract. Periphragm produced into 15 hollow, proximally and distally flaring processes. These are distally denticulate and intratabular, one per reflected plate area indicating a tabulation pattern 1′, 6″, 6‴, 1p, 1⁗. All processes bear longitudinal cord-like thickenings which extend onto the body surface and may join with those from neighbouring processes. The cingular zone is free of processes and the epitractal processes are generally smaller than the hypotractal ones. Archeopyle apical, formed by loss of plate 1′.

Observed Dimensions: Main Body 35(28)22 x 27(23)19$\mu$.
Overall 57(50)41 x 54(43)32$\mu$.
Specimens Measured — 15.

Observed Range: Valanginian to Barremian.

Previously Reported Range: Barremian.

Genus *Endoscrinium* (KLEMENT 1960) VOZZHENNIKOVA 1965 emend. GOCHT 1970

*Endoscrinium campanula* (GOCHT 1959) VOZZHENNIKOVA 1967

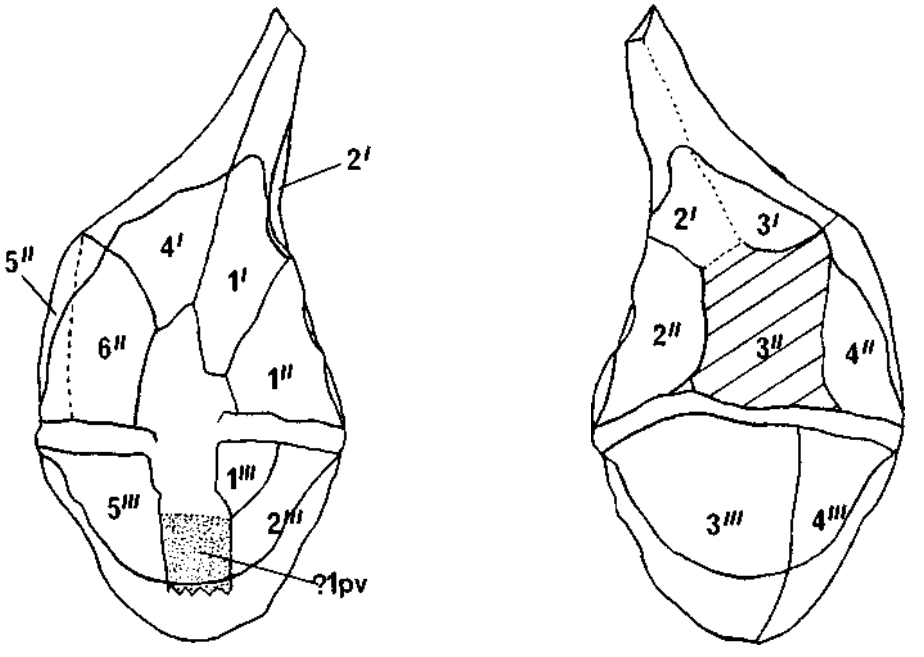
(pl. 10, fig. 5)

1959 *Scriniodinium campanula* GOCHT, p. 61, pl. 4, fig. 6, pl. 5, fig. 1.
1967 *Endoscrinium campanula* — VOZZHENNIKOVA, p. 175, pl. 98, figs. 1—3.

Observed Dimensions: Overall 119(95)80 x 105(78)61$\mu$.
Specimens Measured — 29.

Observed Range: Berriasian to Barremian.

Previously Reported Range: Valanginian to Turonian.




Text-fig. 8. Camera lucida drawings of *Endoscrinium pharo* n. sp. x 620.

*Endoscrinium pharo* n. sp.

(pl. 9, fig. 5, text-fig. 8)

Derivation of Name: From the Greek *pharos*, lighthouse, beacon — in reference to the well-developed apical prominence.

Holotype: Pl. 9, fig. 5.

Type Locality: Division D4/D5, Speeton Clay, Speeton, England.

Diagnosis: A thin-walled, fairly large, cavate cyst. Periblast smooth to finely granular and apically produced into a characteristically long, distally open horn which tapers towards the apex. Endoblast smooth, ovoidal, longer than broad and with a prominent, bluntly-rounded apical prominence. A faint tabulation is outlined on the periphragm by narrow, low, smooth ridges. Tabulation ?4, 6″, 5‴, ?1pv, ?⁗. Archeopyle precingular, formed by loss of plate 3″. Sometimes an additional opening occurs in the periphragm, possibly corresponding to 1 pv.

Observed Dimensions: Holotype 119 x 70$\mu$.
Overall 141(121)90 x 78(70)57$\mu$.
Specimens Measured — 7.

Observed Range: Berriasian and Valanginian.

Remarks: In possessing a distinct apical horn and in the general shape of the test other than the apical horn, *Endoscrinium pharo* resembles *Endoscrinium campanula* (Gocht) Vozzhennikova. The main difference between the two is the degree of development of the apical horn. That of *E. pharo* is always very well-developed (usually about 40 microns long) as opposed to the short horn of *E. campanula*. The difference in horn length between these two species results in a considerable difference in the average overall length of the test.

Genus *Gardodinium* Alberti 1961

*Gardodinium trabeculosum* (Gocht 1959) Alberti 1961

(pl. 10, fig. 7)

1959 *Scriniodinium trabeculosum* Gocht, pp. 62, 63, pl. 4, fig. 5, pl. 8, fig. 2.
1961 *Gardodinium eisenacki* Alberti, p. 18, pl. 3, figs. 8—13.
1961 *Gardodinium* cf. *trabeculosum* Alberti, pp. 18, 19, pl. 3, fig. 7.

Observed Dimensions: Overall 85(76)66 x 72(61)52$\mu$.
Specimens Measured — 11.

Observed Range: Hauterivian and Barremian.

Previously Reported Range: Hauterivian to Aptian.

Remarks: The suggestion that *Gardodinium eisenacki* is a junior synonym of *Gardodinium trabeculosum* was first made by Davey (1974).

Genus *Gonyaulacysta* Deflandre 1964 ex Norris & Sarjeant 1965 emend. Sarjeant 1969

Remarks: The genus *Gonyaulacysta* embraces a wide variety of forms which may be regarded as being of two basic types. These are discussed briefly below.

Throughout the present study, species of *Gonyaulacysta* have been encountered which are of the same general form as the *Gonyaulacysta helicoidea* (Eisenack & Cookson) — *Gonyaulacysta cretacea* (Neale & Sarjeant) type of cyst. These are usually small, thin-walled with a short apical prominence and possessing regularly denticulate sutural crests and a reduced plate 1‴. As pointed out by Neale & Sarjeant (1962, p. 443), this type of cyst is probably descended along an evolutionary line from *Gonyaulacysta jurassica* (Deflandre) Norris & Sarjeant. Such forms described here are *Gonyaulacysta cassidata* (Eisenack & Cookson) Sarjeant, *Gonyaulacysta cretacea* (Neale & Sarjeant) Sarjeant, *Gonyaulacysta diutina* n. sp., *Gonyaulacysta exsanguia* n. sp., *Gonyaulacysta fastigiata* n. sp., *Gonyaulacysta helicoidea* (Eisenack & Cookson) Sarjeant, *Gonyaula-*

*cysta kostromiensis* (VOZZHENNIKOVA) SARJEANT, *Gonyaulacysta ordocava* n. sp. and *Gonyaulacysta perforobtusa* n. sp. Most of these forms are fairly rare and have restricted stratigraphical ranges. However, *Gonyaulacysta diutina* n. sp. and *Gonyaulacysta exsanguia* n. sp. are seen through most of the studied section.

The *Gonyaulacysta helicoidea* (EISENACK & COOKSON) SARJEANT — *Gonyaulacysta cretacea* (NEALE & SARJEANT type of cyst contrasts strongly with a second, distinctive group which is characterised by being generally larger, thicker-walled and altogether more robust than the above group. This more robust group includes many Jurassic and Cretaceous forms of *Gonyaulacysta* as well as the genus *Cribroperidinium*. *Gonyaulacysta* species described here which may be assigned to this group are *Gonyaulacysta cladophora* (DEFLANDRE) DODEKOVA and *Gonyaulacysta* confossa n. sp.

### *Gonyaulacysta cassidata* (EISENACK & COOKSON 1960) SARJEANT 1966a

(pl. 3, fig. 2)

1960 *Gonyaulax helicoidea* subsp. *cassidata* EISENACK & COOKSON, p. 3, pl. 1, figs. 5, 6.
1966a *Gonyaulacysta cassidata* — SARJEANT, pp. 125, 126, pl. 14, figs. 3, 4, text-fig. 31.

Observed Dimensions: Overall 70(68)65 x 57(53)49$\mu$.
Specimens Measured — 6.
Observed Range: Hauterivian.
Previously Reported Range: Barremian to Cenomanian.

### *Gonyaulacysta cladophora* (DEFLANDRE 1938) DODEKOVA 1967

(pl. 2, fig. 5)

1938 *Gonyaulax cladophora* DEFLANDRE, p. 173, pl. 7, figs. 1—5, text-figs. 5, 6.
1967 *Gonyaulacysta cladophora* — DODEKOVA, pp. 17, 18, pl. 2, figs. 2—8.

Observed Dimensions: Overall 168(127)99 x 165(124)90$\mu$.
Specimens Measured — 24.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Bajocian to Kimmeridgian.

Remarks: The specimens of *Gonyaulacysta cladophora* seen in the present work must certainly be reworked from the Jurassic. None were recorded from the Berriasian or from the greater part of the Valanginian and this may be stratigraphically useful, at least in the geographical area immediate to Speeton.

### *Gonyaulacysta confossa* n. sp.

(pl. 2, figs. 2—4)

Derivation of Name: From the Latin *confossus*, pierced through, full of holes — in reference to the completely perforate test.
Holotype: Pl. 2, figs. 3, 4.
Type Locality: Division C1A, Speeton Clay, Speeton, England.

Diagnosis: A species of *Gonyaulacysta* with coarsely perforate test and a long apical horn (this typically measures half the main body length). The tabulation 4′, 6″, 6‴, 1p, 1pv, 1⁗ is outlined by low periphragm crests which are delicate, proximally perforate and distally denticulate. Cingulum distinctly laevorotatory, archeopyle large and formed by detachment of plate 3″.
Observed Dimensions: Holotype 159 x 95$\mu$.
Overall 173(135)108 x 113(92)76$\mu$.
Specimens Measured — 10.
Observed Range: Hauterivian.
Remarks: The coarsely perforate endophragm, long apical horn and delicate sutural crests distinguish this species from all others.

*Gonyaulacysta cretacea* (NEALE & SARJEANT 1962) SARJEANT 1969

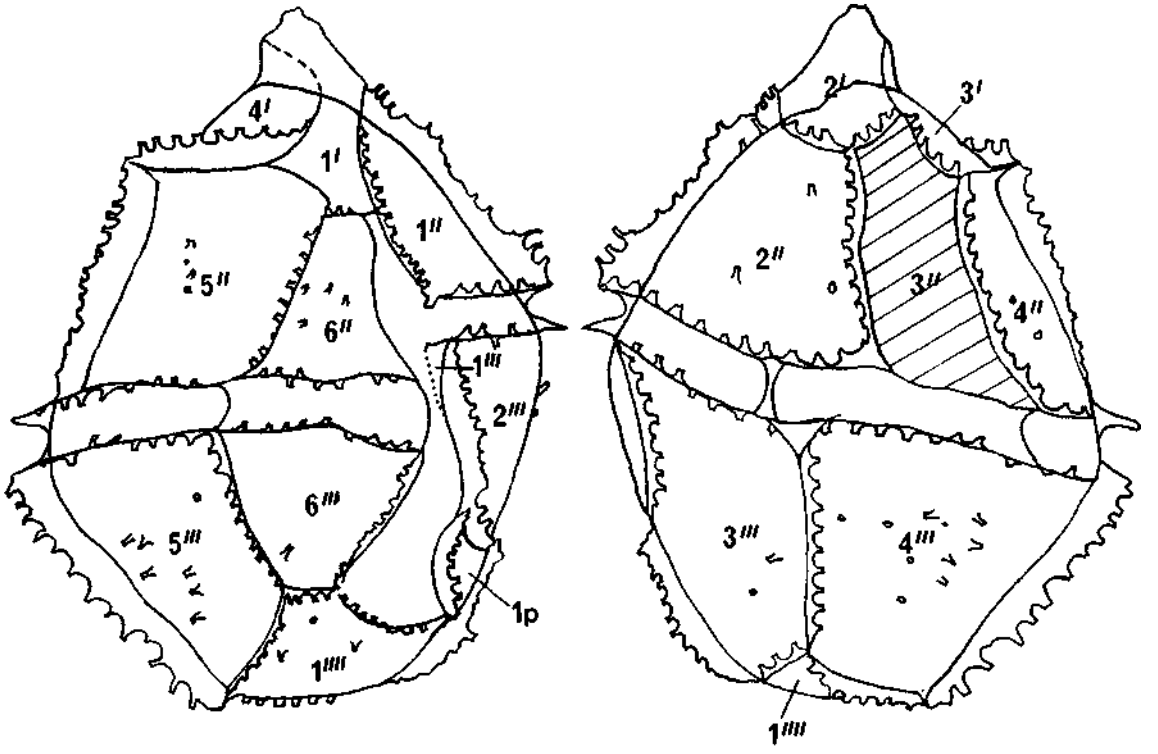
(pl. 1, fig. 5)

1962 *Gonyaulax cretacea* NEALE & SARJEANT, p. 441, pl. 19, figs. 1, 2, text-fig. 2.
1969 *Gonyaulacysta cretacea* — SARJEANT, p. 9.

Observed Dimensions: Overall 53(52)51 x 47(46)44$\mu$.
Specimens Measured — 2.

Observed Range: Hauterivian.

Remarks: Only two specimens were observed in the present study. As indicated by DAVEY & VERDIER (1971), it bears a close resemblance to *Gonyaulacysta helicoidea* (EISENACK & COOKSON) SARJEANT.




Text-fig. 9. Camera lucida drawings of *Gonyaulacysta diutina* n. sp., holotype. x 1400.

*Gonyaulacysta diutina* n. sp.

(pl. 1, figs. 3, 4, text-fig. 9)

Derivation of Name: From the Latin *diutinus*, lasting long — in reference to the long stratigraphical range of this form seen in the present study.

Holotype: Pl. 1, fig. 3, text-fig. 9.

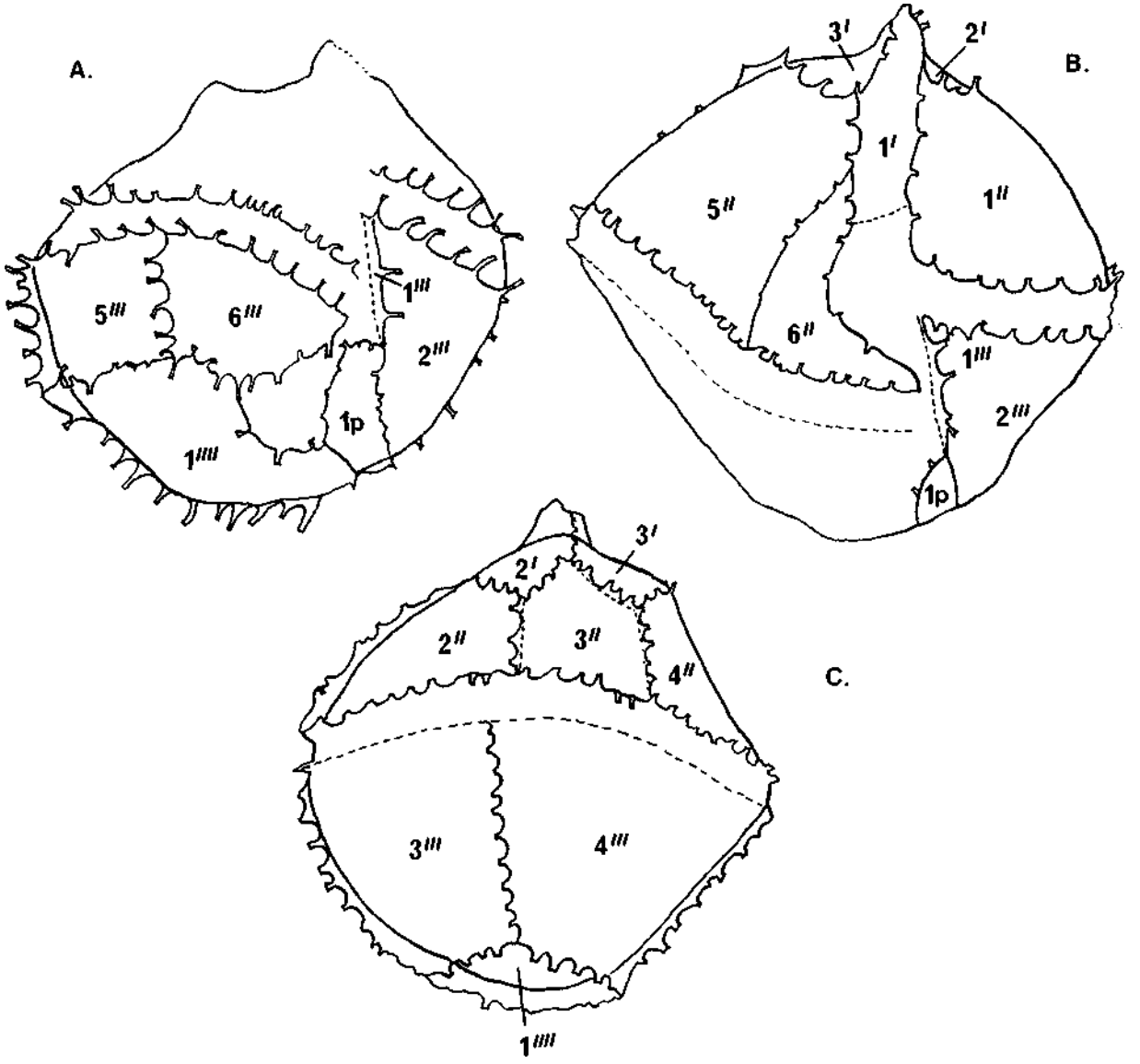
Type Locality: Division D6I, Speeton Clay, Speeton, England.

Diagnosis: A small, proximate cyst. Endophragm ellipsoidal, longer than broad, finely granular with a random scatter of small tubercles. Periphragm smooth to finely granular, produced into fairly low sutural crests which are distally denticulate and which outline a tabulation 4', 6'', 6c, ?6''', 1p, 1''''. Apically, the periphragm is produced into a low horn which is bluntly rounded.

Observed Dimensions: Holotype 65 x 59$\mu$.
Overall 68(63)62 x 59(53)49$\mu$.
Specimens Measured — 9.

Observed Range: Berriasian to Hauterivian.

Remarks: *Gonyaulacysta diutina* may be most closely compared with *Gonyaulacysta helicoidea* (Eisenack & Cookson) Sarjeant as illustrated in Sarjeant 1966a, but differs in several respects. *G. diutina* is more elongate and generally larger. The cyst body of *G. helicoidea* is usually polygonal with a relatively large, flat plate 1'''' whereas that of *G. diutina* is ellipsoidal with a distinctly convex plate 1''''. The apical horn of *G. helicoidea* is the more elongate with usually straight to concave sides as opposed to the bluntly rounded horn of *G. diutina*. Sometimes there is a small pericoel at the base of the horn in *G. diutina*. Most observed specimens of *Gonyaulacysta diutina* had a lateral orientation suggesting some inherent lateral flattening. All specimens of *Gonyaulacysta helicoidea* were seen to have a dorso-ventral compression.




Text-fig. 10. Camera lucida drawings of *Gonyaulacysta exsanguia* n. sp. B. holotype. x 1450.

## *Gonyaulacysta exsanguia* n. sp.

(pl. 1, figs. 6, 7, text-fig. 10)

Derivation of Name: From the Latin *exsanguis*, bloodless, pale, feeble — in reference to the highly transparent, thin-walled nature of this species.

Holotype: Pl. 1, fig. 6, text-fig. 10B.

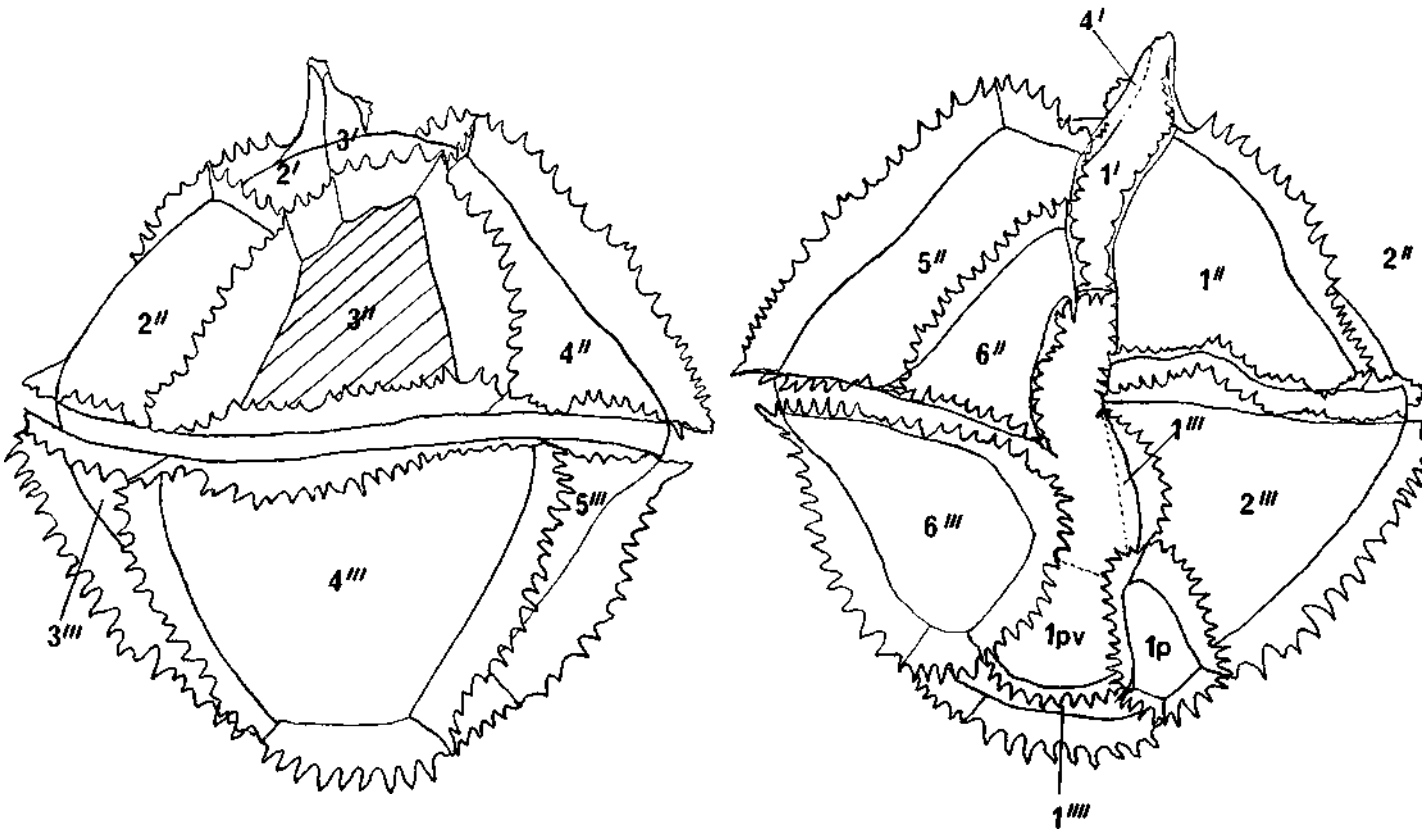
Type Locality: Division C6, Speeton Clay, Speeton, England.

Diagnosis: A small species of *Gonyaulacysta* which is distinctly thin-walled with a finely granular body surface. A short, blunt apical horn is present. Tabulation ?4′, 6″, 6‴, 1p, 1⁗, outlined by low, denticulate sutural crests. Individual denticles fairly broad to slender, flared proximally and distally.

Observed Dimensions: Holotype 57 x 62μ.
Overall 62(54)46 x 62(52)43μ.
Specimens Measured — 15.

Observed Range: Hauterivian and Barremian.

Remarks: The very thin-walled, highly transparent nature of this form, combined with the sutural crest denticulation sets it apart from all others. In the overall test form and thinness of the test walls, *Gonyaulacysta exsanguia* resembles *Gonyaulacysta ordocava* n. sp. The two species are easily distinguishable, however, due to the very distinctive, regularly perforate sutural crests of *Gonyaulacysta ordocava*.




Text-fig. 11. Camera lucida drawings of *Gonyaulacysta fastigiata* n. sp., holotype. x 1450.

*Gonyaulacysta fastigiata* n. sp.

(pl. 1, figs. 8, 9, 12, text-fig. 11)

1959 *Gonyaulax* cf. *serrata* Gocht, pp. 55, 56, pl. 4, fig. 8.

Derivation of Name: From the Latin *fastigio*, to bring to a point, sharpen — in reference to the characteristic sutural denticles.

Holotype: Pl. 1, figs. 8, 12, text-fig. 11.

Type Locality: Division C3, Speeton Clay, Speeton, England.

Diagnosis: Body outline distinctly pentagonal in optical section. Endophragm smooth to finely granular, rounded polygonal without indication of any apical prominence. Periphragm finely granular, developed into fairly high crests which are characteristically distally denticulate. The individual denticles vary from short, regularly tapering elements to well-developed ones (particularly bordering the antapical plate) which flare slightly for two-thirds of their length and then taper sharply. Tabulation ?4′, 6″, ?6‴, 1p, 1pv, 1⁗. Periphragm produced into a prominent apical horn. Archeopyle formed by loss of plate 3″.

Observed Dimensions: Holotype 70 x 68μ.
Overall 81(71)58 x 78(64)54μ.
Specimens Measured — 14.

Observed Range: Hauterivian and Barremian.

Remarks: *Gonyaulacysta fastigiata* is characteristically well-developed in crest denticulation and is characterised by this denticulation and by the polygonal test outline.

*Gonyaulacysta fastigiata* resembles *Gonyaulacysta serrata* (Cookson & Eisenack) Sarjeant. The large difference in size (*G. serrata* was described as 109(105)100 x 100(97)94μ and the detail of the denticulation set the two apart. Also, the apical horn structure of *G. serrata* (as illustrated in Cookson & Eisenack 1958, text-figs. 12—14) is very different to that of *G. fastigiata*. *Gonyaulacysta fastigiata* was described in Gocht 1959 and termed *Gonyaulacysta* cf. *serrata*. Gocht considered the main difference between *G.* cf. *serrata* and *G. serrata* to be one of size.

*Gonyaulacysta helicoidea* (Eisenack & Cookson 1960) Sarjeant 1966a

(pl. 1, fig. 2)

1960 *Gonyaulax helicoidea* Eisenack & Cookson, p. 2, pl. 1, figs. 4, 9.
1966a *Gonyaulacysta helicoidea* — Sarjeant, pp. 116, 117, pl. 13, figs. 7, 8, pl. 15, figs. 8, 9, text-fig. 26.

Observed Dimensions: Overall 61(54)44 x 61(49)40μ.
Specimens Measured — 9.

Observed Range: Hauterivian and Barremian.

Previously Reported Range: Upper Jurassic to Albian.

*Gonyaulacysta kostromiensis* (Vozzhennikova 1967) Sarjeant 1969

(pl. 3, figs. 3, 4, 7)

1967 *Gonyaulax kostromiensis* Vozzhennikova, pp. 85, 86, pl. 26, figs. 1—6, pl. 27, figs. 1, 2.
1969 *Gonyaulacysta kostromiensis* — Sarjeant, p. 10.

Observed Dimensions: Overall 68(55)47 x 53(45)35μ.
Specimens Measured — 15.

Observed Range: Hauterivian.

Previously Reported Range: Valanginian.

Remarks: In 1972, Wiggins transferred *Gonyaulacysta kostromiensis* to his new genus *Nelchinopsis* because of the difference in tabulation pattern and archeopyle type between the specimens he observed and the genus *Gonyaulacysta*. In the present study, the specimens observed were apparently identical to *Gonyaulax kostromiensis* as described by Vozzhennikova; these have a tabulation pattern typical for the genus *Gonyaulacysta*. The species *kostromiensis* is here retained in the genus *Gonyaulacysta*, thus invalidating the genus *Nelchinopsis*. The genus *Alaskadinium* (nom subst. pro *Nelchinopsis*, Wiggins 1972, p. 299) and the species *Alaskadinium wigginsi* are here erected to include forms described as *Nelchinopsis kostromiensis* in Wiggins 1972, pp. 301, 302, pl. 1, figs. A—F, text-fig. 2. The specimen figured in pl. 1, fig. A of Wiggins 1972 is here designated the holotype of *Alaskadinium wigginsi*.

*Gonyaulacysta ordocava* n. sp.

(pl. 1, figs. 10, 11, text-fig. 12)

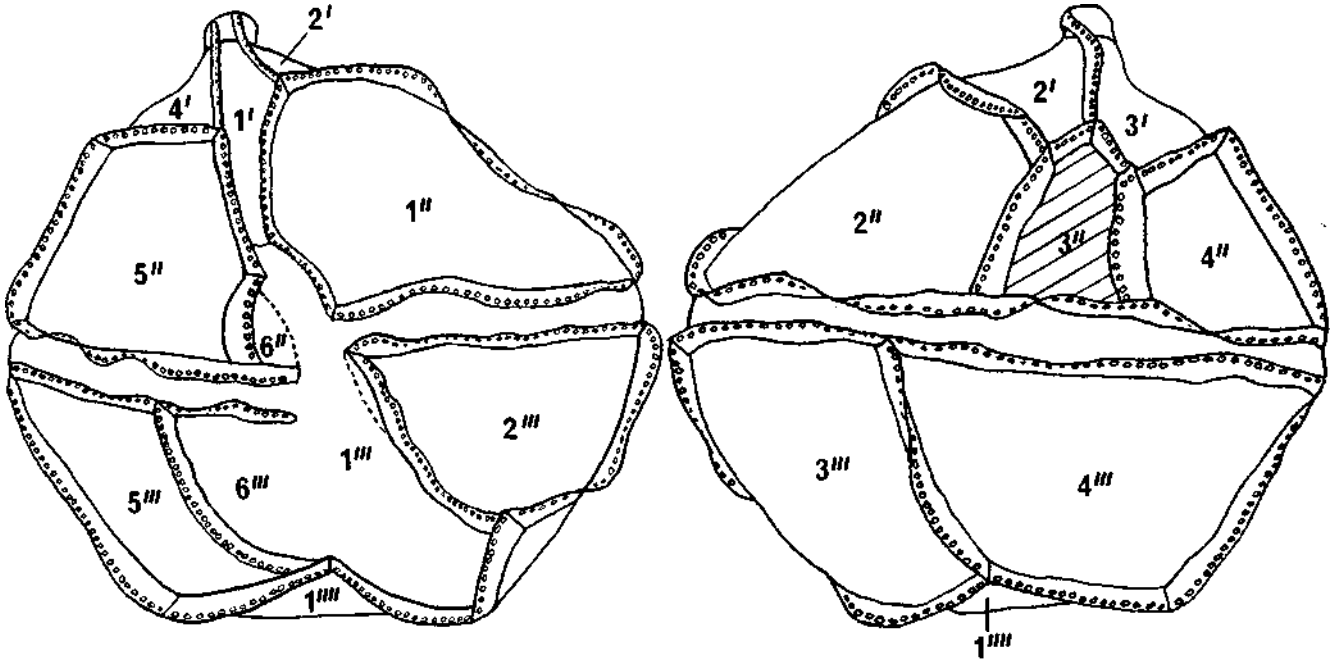
Derivation of Name: From the Latin *ordo*, methodical arrangement, line, row, series and *cavus*, hollow, hole — in reference to the ordered row of holes along the sutural crests.

Holotype: Pl. 1, figs. 10, 11, text-fig. 12.

Type Locality: Division D2D, Speeton Clay, Speeton, England.

Diagnosis: Endophragm thin, smooth to finely granular and produced into a distinct, rounded apical prominence. Periphragm thin, finely granular, produced into a short apical horn. Tabulation 4′, 6″, ?6‴, 1⁗,

outlined by very distinctive sutural crests. These are low, distally entire and of constant height. A regularly-spaced row of perforations each about one micron in diameter occurs in each crest.

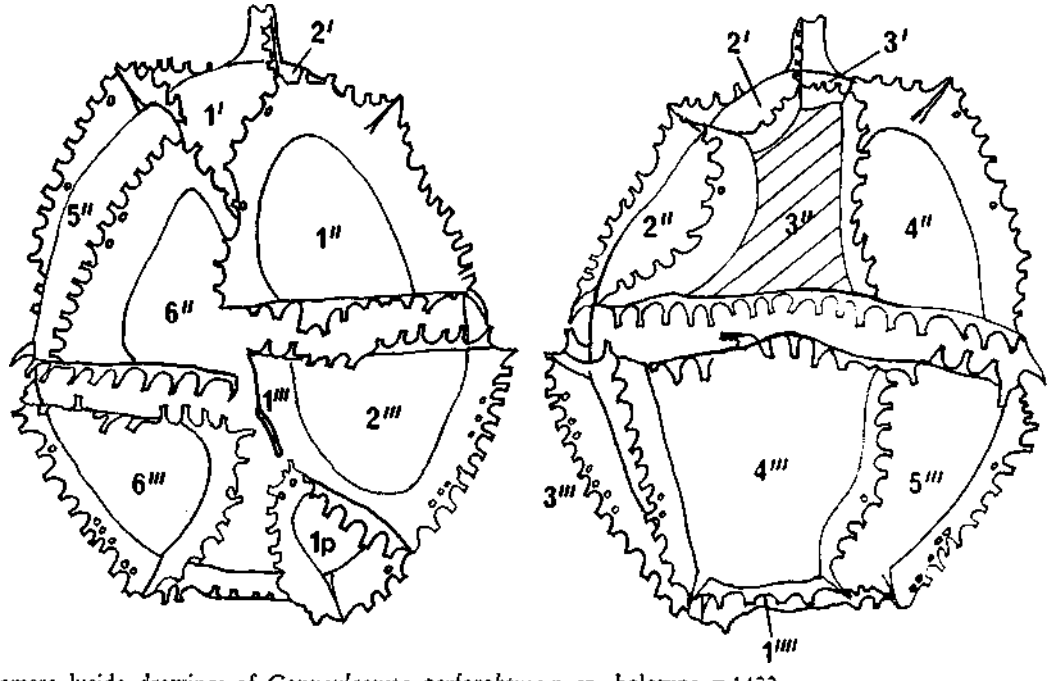



Text-fig. 12. Camera lucida drawings of *Gonyaulacysta ordocava* n. sp., holotype. x 1350.

Observed Dimensions: Holotype 57 x 59$\mu$.
Overall 62(59)58 x 66(61)54$\mu$.
Specimens Measured — 4.

Observed Range: Hauterivian.

Remarks: This is a very distinctive though uncommon species and the regularly perforate sutural crests set it apart from all others. The thinness of the body walls and the overall test form suggests some affinity with *Gonyaulacysta exsanguia* n. sp.




Text-fig. 13. Camera lucida drawings of *Gonyaulacysta perforobtusa* n. sp., holotype. x 1400.

*Gonyaulacysta perforobtusa* n. sp.

(pl. 1, fig. 1, text-fig. 13)

Derivation of Name: From the Latin *perforatus*, perforated and *obtusus*, blunt, dull — in reference to the distinctive perforate crests with blunt denticles.

Holotype: Pl. 1, fig. 1, text-fig. 13.

Type Locality: Division C6, Speeton Clay, Speeton, England.

Diagnosis: Periphragm smooth to finely granular, produced into a short blunt apical horn. Tabulation 4′, 6″, ?6‴, 1p, 1⁗, outlined by very distinctive sutural crests. These are fairly high, proximally entire and distally produced into evenly spaced denticles which are parallel-sided and flat-ended. Typically, just below the line of denticulations, there is a single row of perforations, each being about one micron across.

Observed Dimensions: Holotype 57 x 51$\mu$.
Overall 59(54)46 x 51(46)39$\mu$.
Specimens Measured — 6.

Remarks: In having perforations running along the crests, *Gonyaulacysta perforobtusa* resembles *Gonyaulacysta ordocava* n. sp. However, in most other respects, the two species are very different.

| SPECIES | MAIN BODY SHAPE | SURFACE ORNAMENT | SUTURAL CRESTS | OTHER FEATURES |
|---|---|---|---|---|
| G.cassidata(EISENACK & COOKSON) | Ovoidal | Irregularly scattered tubercles | Irregularly perforate, regularly denticulate | Epitractal pericoel, convex plate 1⁗ |
| G.cretacea(NEALE & SARJEANT) | Distinctly polygonal | None | Irregularly perforate, variable denticles | Flat plate 1⁗ |
| G. diutina n.sp. | Ellipsoidal | Irregularly scattered tubercles | Fairly high with irregular, distally flat denticles | Small apical pericoel, convex plate 1⁗ |
| G. exsanguia n.sp. | Ovoidal to spheroidal | None | Fairly low with the denticles flared proximally and distally | Very thin-walled test |
| G. fastigiata n.sp. | Polygonal | None | Fairly high with sharply pointed denticles | ——— |
| G.helicoidea(EISENACK & COOKSON) | Polygonal | Irregularly scattered tubercles | Denticles very variable in height | Flat plate 1⁗ |
| G.kostromiensis(VOZZHENNIKOVA) | Rounded polygonal | Dense cover of short spines | Generally high and regularly denticulate | Broad-based, delicate apical horn |
| G.ordocava n.sp. | Rounded polygonal | None | Low, distally entire with a single row of perforations in each | Very thin-walled test |
| G.perforobtusa n.sp. | Ellipsoidal | None | Flat-ended denticles, irregular row of crest perforations | ——— |

Text-fig. 14. Tabulation of the salient characteristics of those *Gonyaulacysta helicoidea* (Eisenack & Cookson) — *Gonyaulacysta cretacea* (Neale & Sarjeant) types of cyst described in the present work.

Genus *Heliodinium* Alberti 1961

*Heliodinium voigti* Alberti 1961 emend. Sarjeant 1966a

(pl. 7, figs. 5, 6, pl. 13, fig. 5)

1961 *Heliodinium voigti* Alberti, p. 33, pl. 8, figs. 1—5.
1966a *Heliodinium voigti* — Sarjeant, pp. 142—144, pl. 16, fig. 2, text-fig. 36.

Observed Dimensions: Main Body 66(54)44 x 61(50)41$\mu$.
Processes 39(25)11$\mu$.
Specimens Measured — 17.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Barremian to Cenomanian.
Remarks: In the present work, the sutural processes of this form were seen to be very variable in length. Forms were seen in which these spines were completely reduced over the test with only a few short processes at the antapex. There appears to be a complete range through from this type to the more familiar type with well-developed, equally-long processes.

Genus *Heslertonia* SARJEANT 1966

*Heslertonia heslertonensis* (NEALE & SARJEANT 1962) SARJEANT 1966a

(pl. 11, fig. 7)

1962 *Gonyaulax heslertonense* NEALE & SARJEANT, pp. 440, 441, pl. 19, fig. 5, pl. 20, fig. 5.
1966a *Heslertonia heslertonensis* — SARJEANT, p. 133, pl. 22, fig. 2.

Observed Dimensions: Overall 80(73)66 x 80(69)61$\mu$.
Specimens Measured — 17.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Hauterivian and Barremian.

Genus *Hystrichodinium* DEFLANDRE 1935 emend. CLARKE & VERDIER 1967

*Hystrichodinium furcatum* ALBERTI 1961

(pl. 7, fig. 2)

1961 *Hystrichodinium furcatum* ALBERTI, p. 16, pl. 9, figs. 7, 8.

Observed Dimensions: Main Body 62(51)44 x 58(43)33$\mu$.
Processes (max.) 33(28)22$\mu$.
Specimens Measured — 12.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian and Barremian.

*Hystrichodinium pulchrum* DEFLANDRE 1935

(pl. 13, fig. 9)

1935 *Hystrichodinium pulchrum* DEFLANDRE, pp. 229, 230, pl. 5, fig. 1.

Observed Dimensions: Main Body 66(52)40 x 55(48)35$\mu$.
Processes (max.) 34(28)20$\mu$.
Specimens Measured — 14.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Valanginian to Senonian.

Genus *Kleithriasphaeridium* DAVEY 1974

*Kleithriasphaeridium corrugatum* DAVEY 1974

(pl. 7, figs. 1, 3)

1959 *Hystrichosphaeridium eoinodes* GOCHT, pl. 3, fig. 5 only.
1974 *Kleithriasphaeridium corrugatum* DAVEY, p. 56, pl. 5, figs. 1—5, text-fig. 3.

Observed Dimensions: Main Body 55(50)41 x 55(44)33μ.
Processes (max.) 39(34)28μ.
Specimens Measured — 10.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Barremian.

*Kleithriasphaeridium eoinodes* (EISENACK 1958) DAVEY 1974

(pl. 7, fig. 7)

1958 *Hystrichosphaeridium eoinodes* EISENACK, p. 402, pl. 27, figs. 3, 4.
1963 *Cordosphaeridium eoinodes* — EISENACK, p. 262.
1974 *Kleithriasphaeridium eoinodes* — DAVEY, p. 58.

Observed Dimensions: Main Body 50(44)40 x 50(41)36μ.
Processes (max.) 29(26)22μ.
Specimens Measured — 9.
Observed Range: Berriasian to Hauterivian.
Previously Reported Range: Valanginian to Aptian.

*Kleithriasphaeridium fasciatum* (DAVEY & WILLIAMS 1966b) DAVEY 1974

(pl. 7, figs. 4, 9)

1966b ?*Cordosphaeridium fasciatum* DAVEY & WILLIAMS, pp. 90, 91, pl. 7, figs. 5, 6.
1974 *Kleithriasphaeridium fasciatum* — DAVEY, p. 58.

Observed Dimensions: Main Body 52(47)40 x 50(43)36μ.
Processes (max.) 25(20)14μ.
Specimens Measured — 16.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Barremian.

Remarks: *Kleithriasphaeridium fasciatum* (DAVEY & WILLIAMS) DAVEY is very closely related to *Kleithriasphaeridium corrugatum* DAVEY, the two being separable only on process length, the former bearing short and the latter long processes.

*Kleithriasphaeridium simplicispinum* (DAVEY & WILLIAMS 1966b) DAVEY 1974

(pl. 13, fig. 7)

1959 *Hystrichosphaeridium eoinodes* GOCHT, pl. 3, fig. 6 only.
1966b *Hystrichosphaeridium simplicispinum* DAVEY & WILLIAMS, pp. 59, 60.
1974 *Kleithriasphaeridium simplicispinum* — DAVEY, pp. 57, 58, pl. 6, figs. 1—3, text-fig. 4.

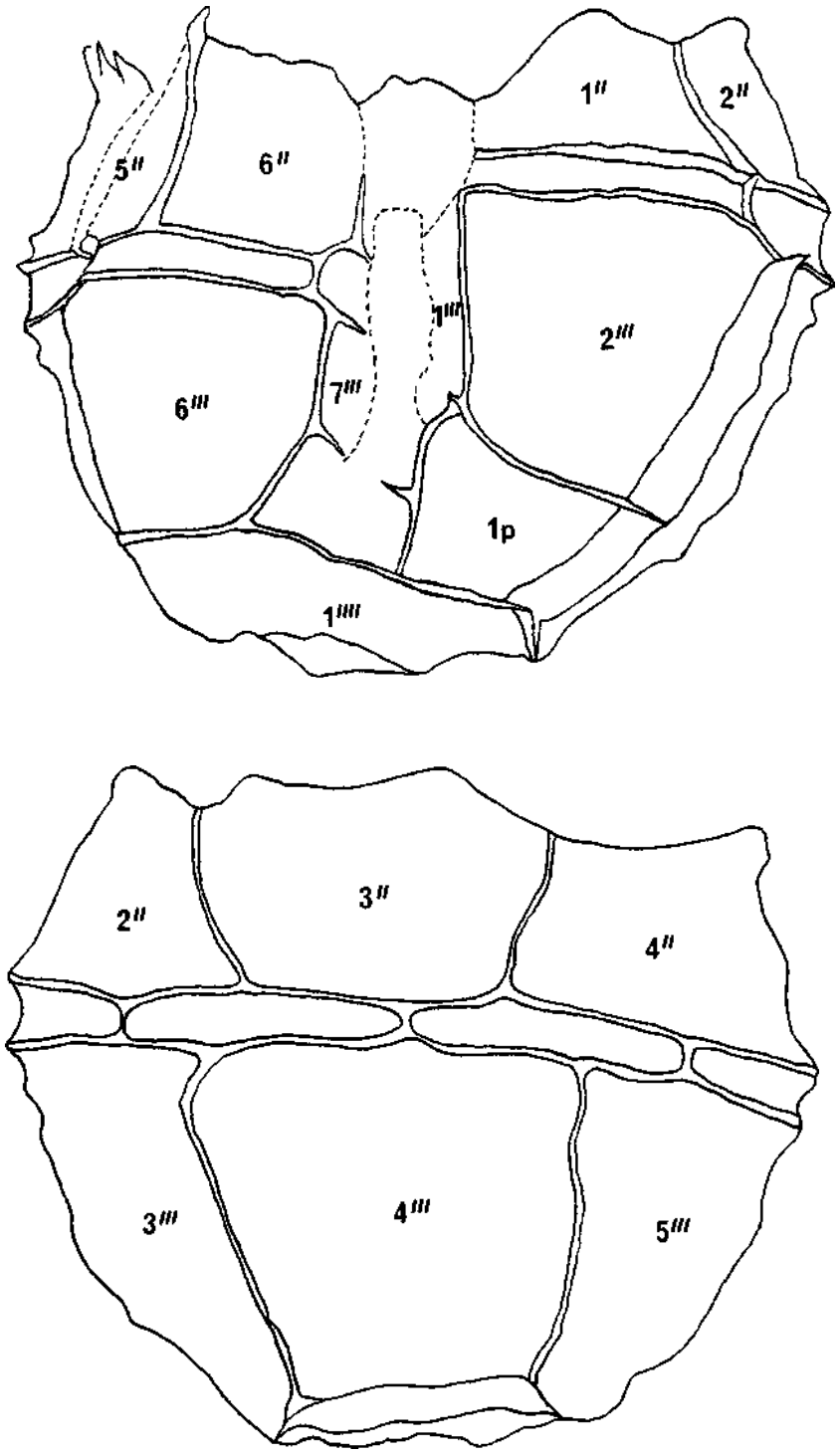
Observed Dimensions: Main Body 66(49)40 x 57(46)39μ.
Processes (max.) 33(27)22μ.
Specimens Measured — 12.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian and Barremian.

Genus *Lithodinia* EISENACK 1935 emend. GOCHT 1975

*Lithodinia pertusa* n. sp.

(pl. 8, fig. 5, text-fig. 15)

Derivation of Name: From the Latin *pertusus*, perforated — in reference to the completely perforate test.
Holotype: Pl. 8, fig. 5, text-fig. 15.
Type Locality: Division D2 A/B, Speeton Clay, Speeton, England.




Text-fig. 15. Camera lucida drawings of *Lithodinia pertusa* n. sp., holotype. x 1200.

Diagnosis: A fairly thick-walled proximate cyst. Test wall perforate with very low sutural crests outlining the tabulation 4', 6'', 7c, 7''', 1p, 1pv, 1''''. Archeopyle apical.

Observed Dimensions: Holotype 76 x 81$\mu$.
Archeopyle Formed 76(68)65 x 86(75)68$\mu$.
Specimens Measured — 7.

Observed Range: Berriasian to Hauterivian.

Remarks: The form which bears the closest resemblance to *Lithodinia pertusa* is that described as *Gonyaulax bulloidea* in COOKSON & EISENACK 1960band later transferred to *Meiourogonyaulax* in SARJEANT 1969. However, in their diagnosis of *Gonyaulax bulloidea*, COOKSON & EISENACK refer to the "granular" nature of both plates and crests. The plates and crests of *Lithodinia pertusa* are distinctly perforate.

*Lithodinia stoveri* (MILLIOUD 1969) n. comb.

(pl. 13, fig. 2)

1969 *Meiourogonyaulax stoveri* MILLIOUD, p. 429, pl. 3, figs. 1—3.

Observed Dimensions: Complete Specimens — Overall 92(80)70 x 76(69)57$\mu$.
Specimens Measured — 5.
Archeopyle Formed — Overall 84(76)68 x 73(70)68$\mu$.
Specimens Measured — 2.

Observed Range: Hauterivian.

Previously Reported Range: Hauterivian to Aptian.

Remarks: The transfer of this species into *Lithodinia* by GOCHT (GOCHT 1975) was invalid. It is therefore effected here.

Genus *Nematosphaeropsis* DEFLANDRE & COOKSON 1955 emend. WILLIAMS & DOWNIE 1966

*Nematosphaeropsis scala* n. sp.

(pl. 9, fig. 2)

Derivation of Name: From the Latin *scala*, flight of stairs, ladder — in reference to the ladder-like trabecular connection.

Holotype: **Pl. 9, fig. 2.**

Type Locality: Division D2E, Speeton Clay, Speeton, England.

Diagnosis: A chorate cyst. The main body is ovoidal to spheroidal and the endophragm and periphragm are closely appressed, except along body sutures where fairly long processes are developed. These processes are proximally connected by low sutural ridges and are distally widely flared and fenestrate. Each gonal process is connected to three neighbouring processes by distal trabeculae and each sutural process to two. These trabeculae are formed of two thin, parallel strands which are connected at various points along their length either by lateral fusion or by short cross-strands.

Observed Dimensions: Holotype 86 x 86$\mu$.
Overall 94(80)69 x 86(75)66$\mu$.
Specimens Measured — 14.

Observed Range: Valanginian and Hauterivian.

Remarks: The trabecular connections which are the characteristic feature of this species are seen entire only in well-preserved specimens. Commonly, the trabeculae are partially broken and sometimes are completely destroyed leaving the nevertheless distinctive widely flared and fenestrate processes. In some respects, *Nematosphaeropsis scala* resembles *Spiniferites ramosus* subsp. *primaevus* n. subsp., particularly in the tendency of the latter to have some perforation of the process terminations and some cross-connection between terminal spines in each process.

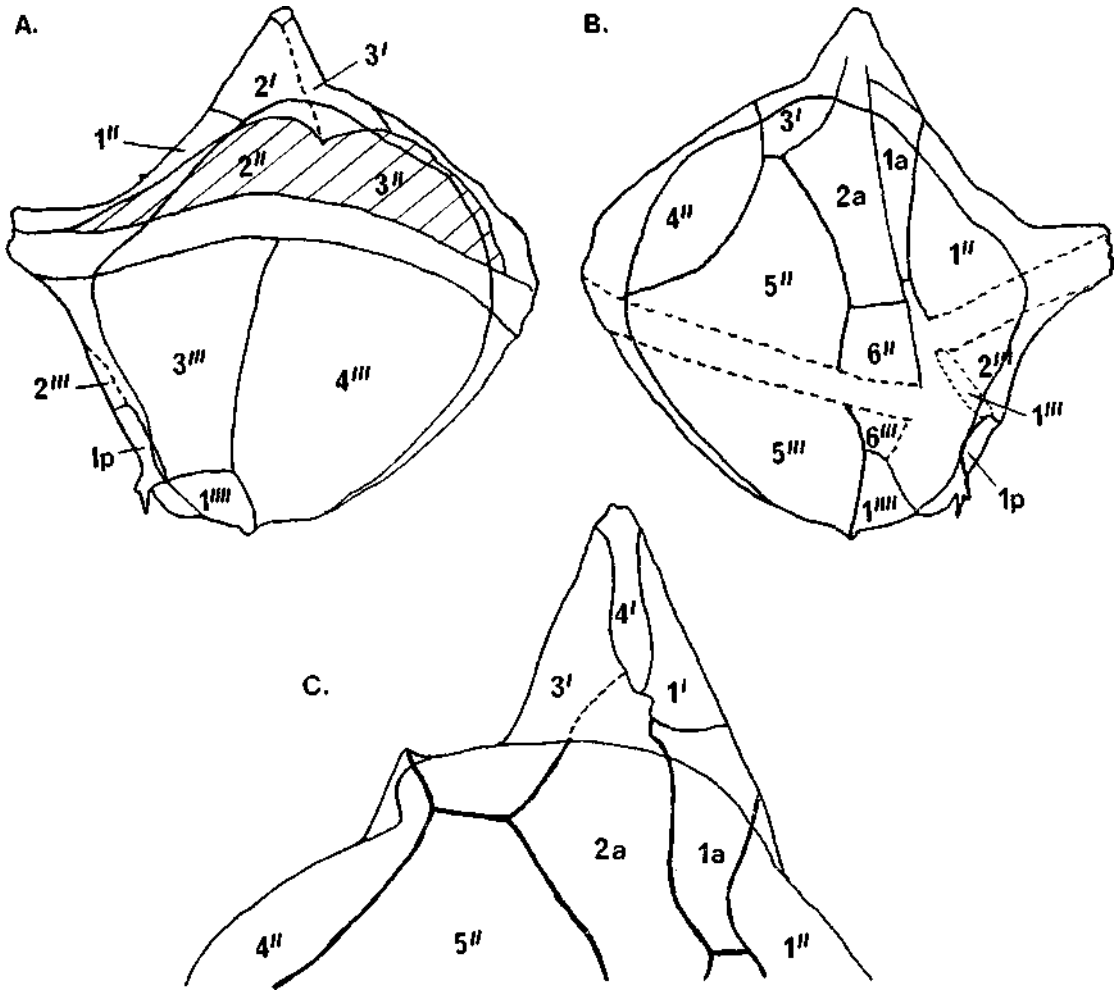
Genus *Occisucysta* GITMEZ 1970

*Occisucysta evitti* (DODEKOVA 1969) GITMEZ 1970

(pl. 3, figs. 1, 5)

1969 *Gonyaulacysta evitti* DODEKOVA, pp. 14, 15, pl. 1, figs. 1—6, pl. 2, figs. 1, 2, text-fig. A.
1970 *Occisucysta evitti* — GITMEZ, p. 269.

Observed Dimensions: Overall 92(80)72 x 90(75)57$\mu$.
Specimens Measured — 11.
Observed Range: Berriasian and Valanginian.
Previously Reported Range: Tithonian.




Text-fig. 16. Camera lucida drawings of *Occisucysta tentoria* n. sp. A & B show the overall tabulation pattern. C. shows most of the ventral epitract. A & B x 1000, C x 1750.

*Occisucysta tentoria* n. sp.

(pl. 3, figs. 8, 9, text-fig. 16)

Derivation of Name: From the Latin *tentorium*, tent — in reference to the characteristic apical horn.
Holotype: Pl. 3, figs. 8, 9.
Type Locality: Division D2D, Speeton Clay, Speeton, England.

Diagnosis: A proximate cyst with a long (about one-third the main body diameter), broad-based, distally closed apical projection. The periphragm is thin and finely granular and the endophragm is fairly thick. The tabulation 4', 2a, 6'', 6''', 1p, 1'''' is outlined on the periphragm by generally low, distally denticulate crests. Cingulum laevo-rotatory and bordered by high crests giving the impression in optical section of lateral extensions to the periphragm. In contrast, the crests on the apical projection are particularly low. Archeopyle large, precingular and formed by loss of plates 2'' and 3''.

Observed Dimensions: Holotype 76 x 86$\mu$.
Overall 83(72)57 x 87(72)61$\mu$.
Specimens Measured — **11**.
Observed Range: Berriasian to Barremian.
Remarks: The large apical prominence and distinctly polygonal outline set this form apart from all others.

Genus *Oligosphaeridium* Davey & Williams 1966

*Oligosphaeridium asterigium* (Gocht 1959) Davey & Williams 1969

(pl. 6, figs. 1—4)

1959 *Hystrichosphaeridium asterigium* Gocht, pp. 67, 68, pl. 3, fig. 1, pl. 7, figs. 1—4.
1962 *Hystrichosphaeridium vasiformum* Neale & Sarjeant, p. 452, pl. 20, fig. 1, text-fig. 8b.
1966b *Oligosphaeridium vasiformum* — Davey & Williams, pp. 74, 75, pl. 9, fig. 7, pl. 10, fig. 1, text-fig. 1.
1969 ?*Oligosphaeridium asterigium* — Davey & Williams, p. 5.

Observed Dimensions: Main Body 66(55)42 x 56(47)36$\mu$.
Processes (max.) 52(42)28$\mu$.
Specimens Measured — 33.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Valanginian to Barremian.
Remarks: *Oligosphaeridium vasiformum* is here considered to be a junior synonym of *Oligosphaeridium asterigium*. In the present study, forms were observed which constituted a complete series from those in which the distal extremes of the processes are not flared and almost closed to forms in which they are very flared. As a general rule, it appears that the width of the process extremes, including the terminal spines, is a fairly constant feature. That is, the wider the flaring, the shorter the terminal spines. The main characteristic feature of this species is the presence of four to seven regularly spaced terminal spines around the distal extremes of the processes. These terminal spines may be distally bifurcate. *Oligosphaeridium asterigium* may be distinguished from *Oligosphaeridium complex* (White 1842) Davey & Williams 1966b by the presence in the former of usually identical terminal spines which are evenly spaced around the open process ends. *Oligosphaeridium complex* bears irregularly spaced terminal spines of varying form on a given process.

*Oligosphaeridium complex* (White 1842) Davey & Williams 1966b

(pl. 5, fig. 8)

1842 *Xanthidium tubiferum complex* White, p. 39, pl. 4, fig. 11.
1848 *Xanthidium complexum* Bronn, p. 1375.
1940 *Hystrichosphaeridium elegantulum* Lejeune—Carpentier, p. B222, text-figs. 11, 12.
1946 *Hystrichosphaeridium complex* — Deflandre, p. 111.
1962 *Hystrichosphaeridium tubiferum* — Pocock, p. 83, pl. 15, fig. 230.
1964 *Hystrichosphaeridium complex* — Cookson & Hughes, p. 46, pl. 9, fig. 6.
1966b *Oligosphaeridium complex* — Davey & Williams, p. 71, pl. 7, figs. 1, 2, pl. 10, fig. 3, text-fig. 14.

Observed Dimensions: Main Body 65(55)46 x 55(45)37$\mu$.
Processes (max.) 44(36)29$\mu$.
Specimens Measured — 16.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Valanginian to Ypresian.

*Oligosphaeridium pulcherrimum* (Deflandre & Cookson 1955) Davey & Williams 1966b

(pl. 6, fig. 5)

1955 *Hystrichosphaeridium pulcherrimum* Deflandre & Cookson, p. 270, pl. 1, fig. 8, text-figs. 21, 22.
1966b *Oligosphaeridium pulcherrimum* — Davey & Williams, p. 75, pl. 10, fig. 9, pl. 11, fig. 5.

Observed Dimensions: Main Body 60(52)46 x 55(48)39$\mu$.
Processes (max.) 46(33)28$\mu$.
Specimens Measured — 7.

Observed Range: Hauterivian and Barremian.

Previously Reported Range: Kimmeridgian (doubtful attribution), Valanginian to Santonian, Eocene (probable reworking).

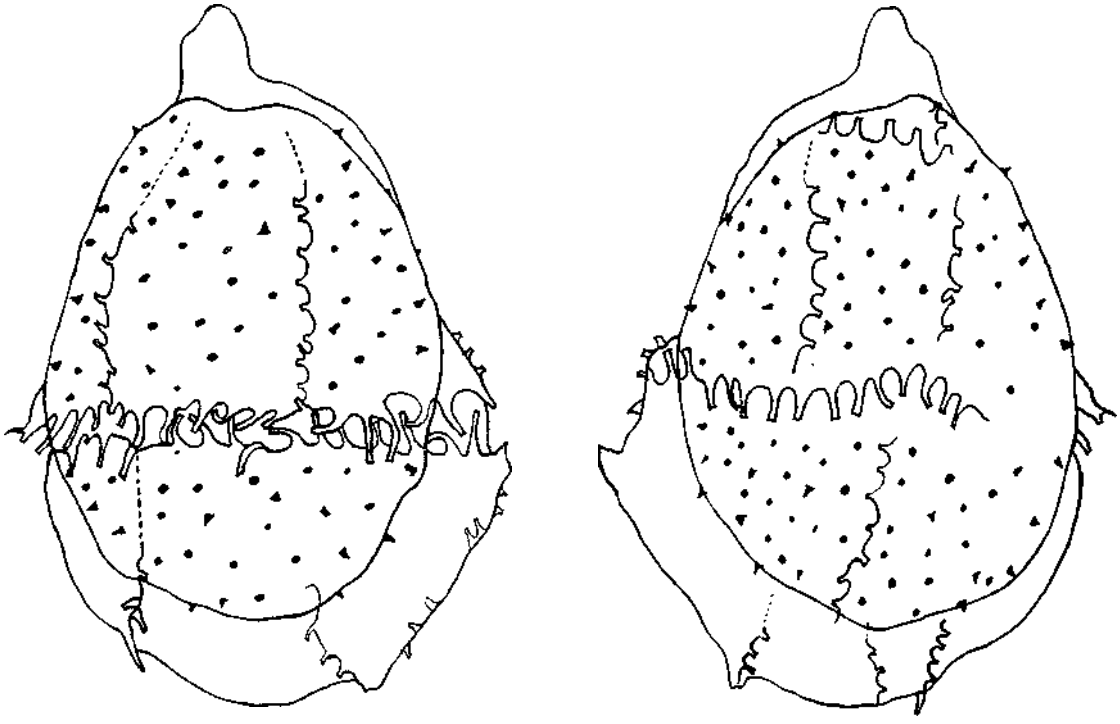
Genus *Parvocavatus* GITMEZ 1970

*Parvocavatus spinosus* n. sp.

(pl. 9, fig. 3, text-fig. 17)

1961 *Forma E* EVITT, p. 391, pl. 3, figs. 9—14, pl. 5, fig. 7.

Derivation of Name: From the Latin *spinosus*, thorny — in reference to the distinctive sutural spines.
Holotype: Pl. 9, fig. 3, text-fig. 17.
Type Locality: Division E, Speeton Clay, Speeton, England.



Text-fig. 17. Camera lucida drawings of *Parvocavatus spinosus* n. sp., holotype. x 1400.

Diagnosis: A proximo-cavate cyst with a fairly short, open apical horn and with the body surface divided into discrete fields by low sutural crests. The ornament of the endoblast consists of numerous short, distally pointed to flattened elements. The periphragm is smooth to finely granular. Each sutural crest bears numerous delicate spines whose length may vary along the crest length. The sutural spines around the cingulum are long compared to those over the rest of the test. Archeopyle apical, formed by a zig-zag split between apical and precingular plates. The operculum is rarely completely detached.

Description: The overall shape is rounded polygonal. The endoblast is usually relatively rigid and intact but the thinner, more delicate periblast is commonly folded and it is only in exceptional specimens that the full extent of the cavation is seen. The surface of the endoblast is covered with short, spinose elements, except at the apical pole which appears devoid of such ornament. Tabulation is outlined on the periphragm by low sutural crests bearing delicate spines. Unfortunately, in the present study it was not possible to formulate a precise tabulation scheme since the large majority of specimens were badly distorted. The tabulation nevertheless

appears typically gonyaulacacean, this being supported by EVITT's illustration (1961, pl. 5, fig. 7). The archeopyle is apical and is formed by splitting of the test along a zig-zag line between the apical and precingular plates. The operculum usually remains attached, probably in the sulcal area as in the genus *Dingodinium*. The degree of cavation is greatest in the hypotract and least in the cingular area. As a rule, the greater the separation of the body layers, the larger the reduction in sutural ornament height at the point of separation. Consequently the cingulum possesses the longest sutural spines.

Observed Dimensions: Holotype 65 x 51$\mu$.
Overall 69(59)51 x 53(43)41$\mu$.
Specimens Measured — 9.
Observed Range: Berriasian.
Previously Reported Range: Upper Jurassic.

Genus *Polysphaeridium* DAVEY & WILLIAMS 1966

*Polysphaeridium laminaspinosum* DAVEY & WILLIAMS 1966b

(pl. 11, fig. 4)

1966b *Polysphaeridium laminaspinosum* DAVEY & WILLIAMS, pp. 94, 95, pl. 8, fig. 8.

Observed Dimensions: Main Body 37(33)30 x 34(30)25$\mu$.
Processes (max.) 22(18)15$\mu$.
Specimens Measured — 8.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian to Cenomanian.

Genus *Prolixosphaeridium* DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966

? *Prolixosphaeridium torynum* (COOKSON & EISENACK 1960b) EISENACK & KJELLSTROM 1971

(pl. 10, fig. 6)

1960b *Hystrichosphaeridium torynum* COOKSON & EISENACK, p. 252, pl. 38, figs. 6, 15.
1971 ?*Prolixosphaeridium torynum* — EISENACK & KJELLSTROM, p. 951.

Observed Dimensions: Archeopyle Formed 77(65)54 x 50(49)46$\mu$.
Specimens Measured — 4.
Observed Range: Berriasian and Valanginian.
Previously Reported Range: ?Tithonian and Neocomian.

Genus *Protoellipsodinium* DAVEY & VERDIER 1971

*Protoellipsodinium spinosum* DAVEY & VERDIER 1971

(pl. 10, figs. 3, 4)

1971 *Protoellipsodinium spinosum* DAVEY & VERDIER, pp. 29, 30, pl. 5, fig. 10.

Observed Dimensions: Main Body 48(44)40 x 40(36)32$\mu$.
Spines 14(9)6$\mu$.
Specimens Measured — 21.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian to Albian.

Genus *Psaligonyaulax* SARJEANT 1966

*Psaligonyaulax apatela* (COOKSON & EISENACK 1960b) SARJEANT 1969

(pl. 10, fig. 2)

1960b *Scriniodinium apatelum* COOKSON & EISENACK, p. 249, pl. 37, figs. 12, 13.
1969 *Psaligonyaulax apatela* — SARJEANT, p. 15.

Observed Dimensions: Overall 102(84)76 x 63(52)46$\mu$.
Specimens Measured — 14.
Observed Range: Berriasian and Valanginian.
Previously Reported Range: Oxfordian to Tithonian.

Remarks: In the overall form of the test, *Psaligonyaulax apatela* much resembles species of *Tubotuberella* VOZZHENNIKOVA 1967. *Psaligonyaulax apatela* was, however, described as possessing no tabulation, a constant feature of *Tubotuberella*. It has been pointed out by WARREN (Ph. D. thesis, 1967, unpublished) that there appears to be a grade of forms attributable to *Psaligonyaulax apatela* from those without tabulation to those with "a nearly complete reflection" (of tabulation). It is possible, therefore, that *Psaligonyaulax apatela* should be placed in the genus *Tubotuberella*.

## Genus *Sirmiodinium* ALBERTI 1961 emend. WARREN 1973

### *Sirmiodinium grossi* ALBERTI 1961 emend. WARREN 1973

(pl. 12, figs. 3, 6—9)

1961 *Sirmiodinium grossi* ALBERTI, p. 22, pl. 7, figs. 5—7, pl. 12, fig. 5.
1973 *Sirmiodinium grossi* — WARREN, pp. 104, 105, pl. 1, figs. 1—16, pl. 2, figs. 1—10, pl. 3, figs. 1—8, text-figs. 3—6.

Observed Dimensions: Overall 105(79)62 x 100(75)59$\mu$.
Specimens Measured — 27.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Kimmeridgian to Barremian.

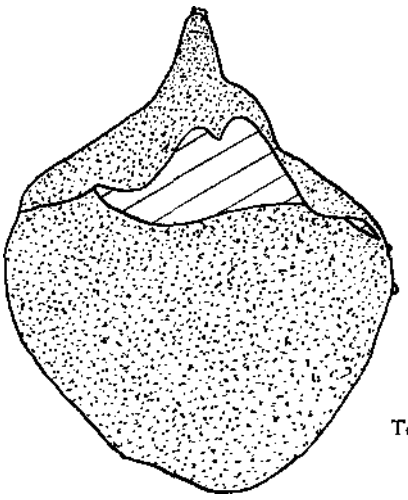
Remarks: All specimens of *Sirmiodinium grossi* observed in the present work ranged in morphology from the type illustrated in plate 1, figure 1 of WARREN 1973 which has a small, rounded test, to that illustrated in plate 1, figure 5 of WARREN 1973, which has a distinctly pentagonal outline. None of the more extreme triangular forms illustrated in WARREN 1973 were seen.

## Genus *Speetonia* n. gen.

Derivation of Name: From Speeton, Yorkshire, England which is the type locality of the Speeton Clay.

Diagnosis: Spheroidal to ovoidal cysts with a strong apical horn which is distally closed. No indication of tabulation except for a large, two-plate precingular archeopyle.

Type Species: *Speetonia delicatula* n. sp.



Text-fig. 18. Camera lucida drawing of *Speetonia delicatula* n. gen. et sp. x 525.

Remarks: The possession of a two-plate precingular archeopyle and of a spheroidal to ovoidal body produced into a strong apical prominence suggest that *Speetonia* is related to *Occisucysta* GITMEZ. However, the total lack of any sutural ornament in *Speetonia* sets it apart from *Occisucysta*, a genus in which sutural orna-

ment is always a most distinctive feature. *Speetonia* differs from *Apteodinium* EISENACK in the possession of a two-plate rather than a single-plate precingular archeopyle and from *Pareodinia* DEFLANDRE emend. WIGGINS in having a precingular rather than an intercalary archeopyle.

*Speetonia delicatula* n. sp.

(pl. 12, figs. 1, 2, 4, 5, text-fig. 18)

Derivation of Name: From the Latin *delicatulus*, delicate — in reference to the delicate test wall.
Holotype: Pl. 2, fig. 4.
*Type Locality: Division D4B, Speeton Clay, Speeton, England.*

Diagnosis: A thin-walled proximate cyst. Test spheroidal to ovoidal, produced into a strong, broad-based projection. The body surface displays no tabulation except for a large, precingular archeopyle formed by the loss of two plates. Body finely to coarsely granular and usually covered by an apparently random scatter of small tubercles. The tip of the apical projection sometimes bears a small, irregular terminal structure.

Observed Dimensions: Holotype 88 x 73$\mu$.
Overall 118(95)75 x 103(82)61$\mu$.
Specimens Measured — 19.

Observed Range: Valanginian.

Remarks: Well-preserved specimens of *Speetonia delicatula* are rare. Usually, the body is folded or broken to some extent. Nevertheless, the large, unornamented test (except for small tubercles) and two-plate precingular archeopyle are usually very distinctive.

Genus *Spiniferites* MANTELL 1850 emend. SARJEANT 1970

*Spiniferites alatus* n. sp.

(pl. 5, fig. 4)

Derivation of Name: From the Latin *alatus*, winged — in reference to the very high sutural crests.
Holotype: Pl. 5, fig. 4.
Type Locality: Division D6I, Speeton Clay, Speeton, England.

Diagnosis: A species of *Spiniferites* with a fairly thick-walled, granular endophragm and periphragm. The periphragm is produced into long (about half main body width) gonal processes which are distally trifurcate. The gonal processes are laterally connected by high, perforate crests which bear bifurcate sutural processes. Archeopyle precingular, probably formed by loss of plate 3″.

Observed Dimensions: Holotype 92 x 86$\mu$.
Overall 92(82)72 x 94(76)63$\mu$.
Specimens Measured — 9.

Observed Range: Berriasian and Valanginian.

*Spiniferites dentatus* (GOCHT 1959) LENTIN & WILLIAMS 1973 emend.

(pl. 4, figs. 5—9)

1959 *Hystrichosphaera? dentata* GOCHT, pp. 75, 76, pl. 4, fig. 11, pl. 7, fig. 19.
1973 *?Spiniferites dentatus* — LENTIN & WILLIAMS, p. 128.

Emended Diagnosis: A fairly thick-walled species of *Spiniferites*. The main body is spheroidal to ellipsoidal, longer than broad. The periphragm is produced into short, trifurcate gonal processes connected along body sutures by high crests. Along the sutural crests are evenly-spaced, broad-based sutural processes. These bifurcate at right angles to the crest length and may subsequently bifurcate again. The sutural process length varies considerably between specimens. Tabulation typical for the genus, archeopyle precingular, formed by loss of plate 3″.

Observed Dimensions: Overall 88(71)55 x 77(68)50$\mu$.
Specimens Measured — 19.
Observed Range: Hauterivian.
Previously Reported Range: Hauterivian and Barremian.

Remarks: The diagnosis of *Spiniferites dentatus* is here emended to include some description of the sutural processes. In GOCHT's original diagnosis, he makes no mention of the bifurcation of these processes, a feature seen in the present work to be very important and variable within the species. However, the specimen figured by GOCHT (1959, pl. 7, fig. 19) clearly illustrates the sutural process bifurcation.

*Spiniferites ramosus* (EHRENBERG 1838) MANTELL 1854 subsp. *granosus* DAVEY & WILLIAMS 1966a

(pl. 5, fig. 5)

1966a *Hystrichosphaera ramosa* var. *granosa* DAVEY & WILLIAMS, p. 35, pl. 4, fig. 9.

Observed Dimensions: Main Body 55(46)37 x 50(39)32$\mu$.
Overall 74(69)63 x 69(62)46$\mu$.
Specimens Measured — 10.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Ypresian.

*Spriniferites ramosus* (EHRENBERG 1838) MANTELL 1854 subsp. *multibrevis* DAVEY & WILLIAMS 1966a

(pl. 4, fig. 4)

1966a *Hystrichosphaera ramosa* var. *multibrevis* DAVEY & WILLIAMS, pp. 35—37, pl. 4, fig. 6.

Observed Dimensions: Main Body 55(45)39 x 50(42)33$\mu$.
Overall 66(60)51 x 62(57)44$\mu$.
Specimens Measured — 17.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Hauterivian to Ypresian.

*Spiniferites ramosus* (EHRENBERG 1838) MANTELL 1854 subsp. *primaevus* nov.

(pl. 4, figs. 2, 3)

Derivation of Name: From the Latin *primaevus*, early, young — in reference to the stratigraphically early occurrence of this form.

Diagnosis: A chorate cyst possessing both gonal and sutural processes. The gonal processes trifurcate, terminating in three flat, distally expanded spines. These terminal spines may be of varying form. They are sometimes distally finely denticulate, sometimes laterally joined by thin trabeculae (on a given process — no connection between processes was observed) and sometimes ending in a distinct bifurcation. Sutural processes may be distally bifurcate. Both gonal and sutural processes may be distally perforate, sometimes approaching small-scale fenestration.

Observed Dimensions: Main Body 51(46)42 x 44(37)33$\mu$.
Overall 75(69)64 x 73(63)55$\mu$.
Specimens Measured — 14.
Observed Range: Valanginian.

Remarks: This subspecies differs from all other subspecies of *Spiniferites ramosus* in the form of the process terminations, particularly in the tendency towards small-scale fenestration and towards distal trabecular connection of terminal spines on a given process.

*Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854 subsp. *ramosus* Davey & Williams 1966a

(pl. 4, fig. 1)

1966a *Hystrichosphaera ramosa* var. *ramosa* Davey & Williams, pp. 33, 34, pl. 1, figs. 1, 6, pl. 3, fig. 1, text-fig. 8.

Observed Dimensions: Main Body 55(45)39 x 50(41)33$\mu$.
Overall 84(63)56 x 77(61)55$\mu$.
Specimens Measured — 14.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Oxfordian (doubtful attribution), Valanginian to Recent.

Genus *Systematophora* Klement 1960

*Systematophora complicata* Neale & Sarjeant 1962

(pl. 7, fig. 8)

1962 *Systematophora complicata* Neale & Sarjeant, pp. 455, 456, pl. 19, figs. 6, 7.

Observed Dimensions: Main Body 50(45)41 x 45(40)35$\mu$.
Processes (max.) 22(21)18$\mu$.
Specimens Measured — 5.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian and Barremian.

*Systematophora schindewolfi* (Alberti 1961) Downie & Sarjeant 1964

(pl. 5, fig. 7)

1961 *Hystrichosphaerina schindewolfi* Alberti, pp. 38, 39, pl. 10, figs. 1—3, 6, 7.
1964 *Systematophora schindewolfi* — Downie & Sarjeant, p. 146.

Observed Dimensions: Main Body 66(61)56 x 55(55)54$\mu$.
Processes (max.) 44(37)33$\mu$.
Specimens Measured — 4.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian, Aptian and Turonian.

*Systematophora vetuscula* (Davey 1974) n. comb.

(pl. 11, fig. 5)

1974 *Adnatosphaeridium vetusculum* Davey, p. 45, pl. 1, figs. 1, 2.

Description: A small chorate cyst. The main body is sub-spherical and finely granular. The periphragm is produced into numerous short, distally pointed elements which appear to be inserted in groups with the elements forming "process complexes". That is, the numerous processes represent a relatively small number of larger, hollow processes. Commonly, the short, spinose elements are connected by trabeculae at right angles to their length, usually near their distal extremes but this may occur at any point along their length. The archeopyle is apical and formed by the detachment of the apical plates along a distinctly zig-zag line.

Observed Dimensions: Complete Specimens — Overall 65(62)58 x 59(57)55$\mu$.
Specimens Measured — 5.
Archeopyle Formed — Overall 64(60)57 x 69(67)65$\mu$.
Specimens Measured — 3.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian.

Remarks: The presence of process complexes (though poorly defined) and an apical archeopyle suggest that this species belongs in the genus *Systematophora* Klement.

Genus *Trichodinium* Eisenack & Cookson 1960 emend. Clarke & Verdier 1967

*Trichodinium ciliatum* (Gocht 1959) Davey 1974

(pl. 13, fig. 1)

1959 *Apteodinium ciliatum* Gocht, p. 65, pl. 8, figs. 5, 6.
1974 *Trichodinium ciliatum* Davey, pp. 62, 63, pl. 7, fig. 1.

Observed Dimensions: Overall 100(81)68 x 96(72)61 $\mu$.
Specimens Measured — 15.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Hauterivian and Barremian.

*Peridiniacean Group*

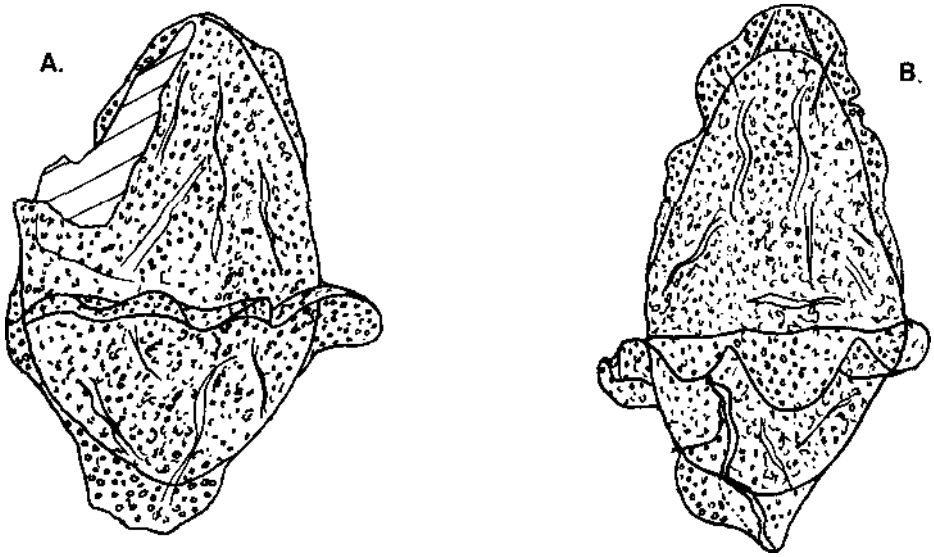
Genus *Aprobolocysta* n. gen.

Derivation of Name: From the Greek *a-*, not and *probolos*, any projecting object or prominence — in reference to the lack of any apical and any well-defined antapical projections.

Diagnosis: Proximate cysts. Cyst wall bi-layered. Endophragm elongate ovoidal, epitract longer and more tapering than hypotract. No indication of tabulation other than by periphragm folds and irregular archeopyle margin. Apex and antapex bluntly rounded. The apex bears no prominence and the antapex sometimes possesses two low, poorly-developed projections. Archeopyle apical.

Type Species: *Aprobolocysta eilema* n. sp.

Remarks: In its mode of archeopyle formation and in its elongate, apically tapering outline, *Aprobolocysta* most closely resembles *Necrobroomea* Wiggins 1975. However, *Necrobroomea* always possesses an apical horn which is usually well-developed, as well as two antapical horns. *Aprobolocysta*, on the other hand, lacks any apical projection and possesses only very poorly-defined antapical projections, if any at all. Further, *Necrobroomea* has a single-layered cyst wall whereas that of *Aprobolocysta* is bi-layered, a character clearly seen due to periphragm folding in the type species.




Text-fig. 19. Camera lucida drawings of *Aprobolocysta eilema* n. gen. et sp. A. Paratype. B. Holotype. x 1500.

*Aprobolocysta eilema* n. sp.

(pl. 14, figs. 4, 5, 8, text-fig. 19)

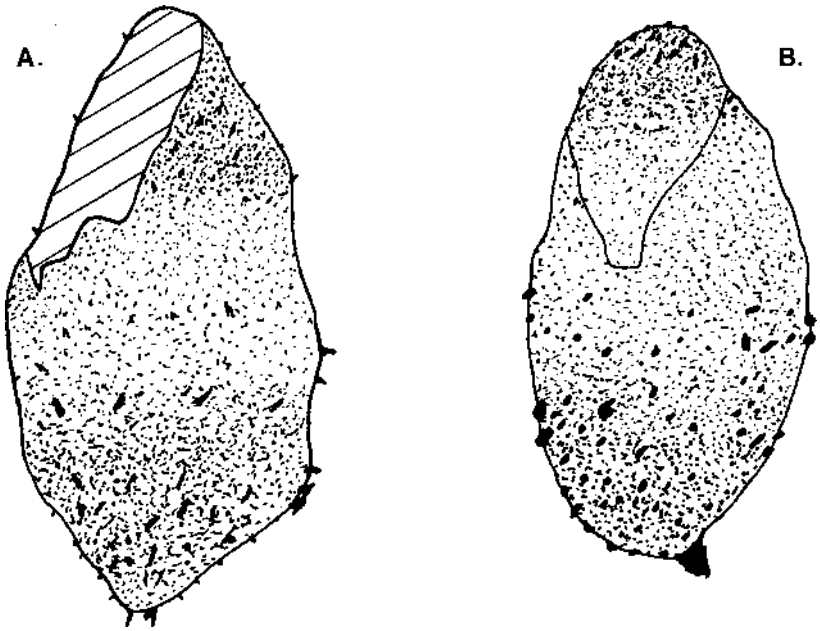
Derivation of Name: From the Greek *eilema*, wrapper, envelope. This refers to the periphragm layer which loosely encloses the endophragm.

Holotype: Pl. 14, figs. 4, 5, text-fig. 19B.
Type Locality: Division C3, Speeton Clay, Speeton, England.

Diagnosis: An elongate ovoidal proximate cyst. Epitract longer and more tapering than hypotract. Endophragm densely granular. Periphragm relatively delicate, finely perforate, usually extensively folded and enclosing the inner body loosely. The cingulum is reflected in a high undulating periphragm fold. A second high periphragm fold runs from the reflected cingulum to the antapex. No tabulation is apparent except along the margin of the apical archeopyle.

Observed Dimensions: Holotype (complete) 73 x 46$\mu$.
Complete Specimens — Overall 75(70)66 x 48(42)38$\mu$.
*Specimens Measured* — 6.
Archeopyle Formed — Overall 73(63)54 x 50(45)35$\mu$.
Specimens Measured — 5.

Observed Range: Hauterivian.




Text-fig. 20. Camera lucida drawings of *Aprobolocysta varigranosa* n. gen. et sp. A. Paratype. B. Holotype. x 1300.

## *Aprobolocysta varigranosa* n. sp.

(pl. 14, figs. 6, 7, text-fig. 20)

Derivation of Name: From the Latin *varius*, different and *granosus*, seedy, full of seeds or grains — in reference to the distinctive granular ornament.

Holotype: Pl. 14, fig. 6, text-fig. 20B.
Type Locality: Division D2D, Speeton Clay, Speeton, England.

Diagnosis: An elongate ovoidal proximate cyst. Surface of body covered with irregular granular ornament which varies in coarseness. The lower third of the body bears well-developed (up to two microns) ornament which becomes gradually finer towards the apex. In the apical region, the ornament is again coarse. There is no apical prominence, but there is some indication at the antapex of two poorly-developed protruberances, normally only represented by local increases in ornament height.

Observed Dimensions: Holotype (complete) 73 x 41$\mu$.
Complete Specimens — Overall 75(72)69 x 46(41)36$\mu$.
Specimens Measured — 5.
Archeopyle Formed — Overall 83(71)61 x 46(41)37$\mu$.
Specimens Measured — 6.

Observed Range: Valanginian and basal Hauterivian.

Remarks: *Aprobolocysta varigranosa* is easily distinguished from *Aprobolocysta eilema* since the former has no obvious separation of endo- and periphragm, variable body ornament and usually some indication of antapical projections, whereas the latter has a distinctive, perforate periphragm, regular, granular endophragm ornament and no apical or antapical projections.

Genus *Deflandrea* Eisenack 1938 emend. Williams & Downie 1966

*Deflandrea terrula* Davey 1974

(pl. 15, fig. 4)

1974 *Deflandrea terrula* Davey, p. 65, pl. 8, figs. 4, 5.

Observed Dimensions: Overall 81(72)62 x 61(55)51$\mu$.
Specimens Measured — 7.

Observed Range: Hauterivian and Barremian.

Previously Reported Range: Barremian.

Genus *Kalyptea* Cookson & Eisenack 1960

Remarks: Throughout the interval studied in the present work, forms referable to the genus *Kalyptea* have been observed. No attempt has been made here to divide these into their particular species.

Genus *Muderongia* Cookson & Eisenack 1958

*Muderongia crucis* Neale & Sarjeant 1962

(pl. 15, fig. 8)

1962 *Muderongia crucis* Neale & Sarjeant, pp. 449, 450, pl. 20, figs. 2, 6.

Observed Dimensions: Archeopyle Formed — Overall 138(131)120 x 132(118)96$\mu$.
Specimens Measured — 9.

Observed Range: Hauterivian and Barremian.

Previously Reported Range: Hauterivian and Barremian.

*Muderongia extensiva* n. sp.

(pl. 15, fig. 10)

1961 *Muderongia tetracantha* (Gocht 1957) Alberti 1961 in Alberti, p. 14, pl. 2, figs. 14—18.

Derivation of Name: From the Latin *extensivus*, spread or stretched out, wide — in reference to the very wide span of the lateral horns.

Holotype: Pl. 15, fig. 10.

Type Locality: Division D2E, Speeton Clay, Speeton, England.

Diagnosis: A species of *Muderongia* with four very prominent horns, one apical, two lateral and one antapical. The last is slightly offset from the antapical pole. The lateral horns are long and extend almost at right angles from the test. They are distally notched and these notches probably reflect the cingulum. Anteriorly, the distal extremes of the cingular notches are produced into short spines. In contrast, they are posteriorly produced into long, backwardly-directed spines. These curve slightly towards the main body of the cyst and taper to sharp points.

Observed Dimensions: Holotype (complete) 227 x 165$\mu$.
Complete Specimens — Overall 227 x 165$\mu$.
Specimens Measured — 1.
Archeopyle Formed — Overall 132(119)99 x 171(149)121$\mu$.
Specimens Measured — 10.

Observed Range: Valanginian and basal Hauterivian.

Remarks: This species was originally described in ALBERTI 1961 as *Muderongia tetracantha* (GOCHT). The lateral horn illustrated in EISENACK 1961, pl. 36, fig. 7, as *Muderongia tetracantha* (GOCHT) probably belongs to this same species. It has been pointed out in HASKELL 1970 and DAVEY 1974 that this species is different from all previously described species of *Muderongia*, more specifically from *Muderongia tetracantha*. The present author is in agreement with this view and *Muderongia extensiva* is described here as a form which is most distinctive, especially in the character of the lateral horns.

### *Muderongia simplex* ALBERTI 1961

(pl. 14, fig. 9)

1961 *Muderongia simplex* ALBERTI, p. 12, pl. 2, figs. 1—6, pl. 12, figs. 1, 2.

Observed Dimensions: Archeopyle Formed — Overall 105(85)70 x 99(80)68$\mu$.
Specimens Measured — 14.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Valanginian to Barremian.

### *Muderongia staurota* SARJEANT 1966b

(pl. 15, fig. 6)

1966b *Muderongia staurota* SARJEANT, pp. 203, 204, pl. 21, figs. 6, 7, text-fig. 53, non pl. 23, fig. 4.

Observed Dimensions: Complete Specimens — Overall 184(181)178 x 107(107)107$\mu$.
Specimens Measured — 2.
Archeopyle Formed — Overall 128(124) 117 x 114(99)84$\mu$.
Specimens Measured — 6.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian and Barremian.

### *Muderongia tetracantha* (GOCHT 1957) ALBERTI 1961

(pl. 15, fig. 5)

1957 *Pseudoceratium ? tetracanthum* GOCHT, pp. 168, 169, pl. 18, figs. 7—9.
1961 *Muderongia tetracantha* — ALBERTI, p. 14, non pl. 2, figs. 14—18.

Observed Dimensions: Archeopyle Formed — Overall 127(120)116 x 100(87)77$\mu$.
Specimens Measured — 3.
Observed Range: Hauterivian.
Previously Reported Range: Hauterivian and Barremian.

## Genus *Necrobroomea* WIGGINS 1975

### *Necrobroomea jaegeri* (ALBERTI 1961) WIGGINS 1975

(pl. 15, fig. 3)

1961 *Broomea jaegeri* ALBERTI, p. 26, pl. 5, figs. 1—7.
1975 *Necrobroomea jaegeri* — WIGGINS, p. 111.

Observed Dimensions: Complete Specimens — Overall 150(113)94 x 40(36)31$\mu$.
Specimens Measured — 6.
Archeopyle Formed — Overall 83(74)68 x 41(37)31$\mu$.
Specimens Measured — 3.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian to Albian.

Remarks: In DAVEY 1974, *Broomea jaegeri* ALBERTI 1961 was considered to be synonymous with *Broomea micropoda* EISENACK & COOKSON 1960. Both species were transferred to *Necrobroomea* in WIGGINS 1971. In the present study, *Necrobroomea jaegeri* is considered to be distinct from *Necrobroomea micropoda* (including *Broomea pellifera* ALBERTI 1961). The length to breadth ratio of the test in *Necrobroomea jaegeri* appears to be consistently higher than in *Necrobroomea micropoda*. No specimens were observed which were transitional between the two.

*Necrobroomea longicornuta* (ALBERTI 1961) WIGGINS 1975

(pl. 15, fig. 2)

1961 *Broomea ? longicornuta* ALBERTI, p. 27, pl. 5, figs. 18—21, pl. 6, figs. 1, 2.
1975 *Necrobroomea longicornuta* — WIGGINS, p. 111.

Observed Dimensions: Complete Specimens — Overall 253(251)248 x 39(38)37$\mu$.
Specimens Measured — 2.
Archeopyle Formed — Overall 155(140)107 x 37(35)31$\mu$.
Specimens Measured — 9.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Hauterivian and Barremian.

*Necrobroomea micropoda* (EISENACK & COOKSON 1960) WIGGINS 1975

(pl. 13, figs. 6, 8)

1960 *Broomea micropoda* COOKSON & EISENACK, p. 7, pl. 2, figs. 8, 9.
1961 *Broomea pellifera* ALBERTI, p. 26, pl. 5, figs. 11—13.
1961 *Pareodinia* spp. EVITT, p. 400, pl. 8, figs. 20, 21, pl. 9, figs. 13, 14.
1975 *Necrobroomea micropoda* — WIGGINS, p. 111.

Observed Dimensions: Complete Specimens — Overall 92(78)61 x 44(40)36$\mu$.
Specimens Measured — 10.
Archeopyle Formed — Overall 66(63)55 x 46(40)35$\mu$.
Specimens Measured — 4.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Upper Jurassic to Albian.

Genus *Pareodinia* DEFLANDRE 1947 emend. WIGGINS 1975

*Pareodinia dasyforma* WIGGINS 1975

(pl. 14, figs. 1—3)

1967 *Imbatodinium villosum* VOZZHENNIKOVA, p. 56, pl. 12, figs. 1—3, pl. 13, figs. 1—3, pl. 14, figs. 1, 2, pl. 15, figs. 1, 2.
1975 *Pareodinia dasyforma* WIGGINS, p. 107, pl. 5, figs. 3, 4.

Observed Dimensions: Main Body 91(74)65 x 40(33)26$\mu$.
Spines (max.) 15(11)8$\mu$.
Specimens Measured — 11.
Observed Range: Berriasian to Hauterivian.
Previously Reported Range: Kimmeridgian to Hauterivian.

Genus *Phoberocysta* MILLIOUD 1967

*Phoberocysta neocomica* (GOCHT 1957) MILLIOUD 1967

(pl. 14, fig. 10)

1957 *Wetzeliella ? neocomica* GOCHT, pp. 172—176, pl. 19, figs. 1—4, pl. 20, figs. 4, 6, 7.
1967 *Phoberocysta neocomica* — MILLIOUD, p. 432, pl. 2, fig. 4, pl. 3, fig. 4.

Observed Dimensions: Complete Specimens — Overall 124(109)94 x 101(87)72$\mu$.
Specimens Measured — 11.
Archeopyle Formed — Overall 115(92)72 x 97(83)61$\mu$.
Specimens Measured — 24.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Berriasian to Aptian.

### Genus *Pseudoceratium* Gocht 1957

### *Pseudoceratium pelliferum* Gocht 1957

(pl. 15, fig. 1)

1957 *Pseudoceratium pelliferum* Gocht, pp. 166—168, pl. 18, figs. 1, 2, text-figs. 1—3.

Observed Dimensions: Complete Specimens — Overall 182(149)105 x 91(76)54$\mu$.
Specimens Measured — 8.
Archeopyle Formed — Overall 150(100)72 x 90(77)62$\mu$.
Specimens Measured — 27.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Valanginian to Albian (?).
Remarks: In all probability, this species ranges no higher than top Barremian.

### Genus *Tenua* Eisenack 1958 emend. Sarjeant 1968

### *Tenua anaphrissa* (Sarjeant 1966b) Benedek 1972

(pl. 15, fig. 9)

1964 *Tenua hystrix* Michael, p. 33, pl. 3, figs. 5, 6.
1966b *Doidyx anaphrissa* Sarjeant, p. 206, pl. 22, fig. 8, pl. 23, fig. 6, text-fig. 55.
1972 *Tenua anaphrissa* — Benedek, pp. 9, 10, pl. 1, fig. 1.

Observed Dimensions: Complete Specimens — Overall 160(134)108 x 132(127)91$\mu$.
Specimens Measured — 14.
Archeopyle Formed — Overall 94(87)77 x 113(105)94$\mu$.
Specimens Measured — 6.
Observed Range: Barremian.
Previously Reported Range: Barremian.
Remarks: As pointed out in Sarjeant 1966b (p. 206), the body outline and mode of archeopyle formation suggest that this species may be derived from the genus *Pseudoceratium* Gocht. Because of this probable relationship, *Tenua anaphrissa* is included in this Peridiniacean Group instead of in the Gonyaulacacean Group where it was placed by Davey (1974).

## Unknown Affinities Group

The genera included in this group do not show any conclusive evidence for their inclusion in the Gonyaulacacean or Peridiniacean Groups.

### Genus *Chlamydophorella* Cookson & Eisenack 1958

### *Chlamydophorella nyei* Cookson & Eisenack 1958

(pl. 9, fig. 6)

1958 *Chlamydophorella nyei* Cookson & Eisenack, p. 56, pl. 11, figs. 1—3.

Observed Dimensions: Overall 55(51)44 x 52(48)39$\mu$.
Specimens Measured — 9.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Barremian to Turonian.

Genus *Fromea* Cookson & Eisenack 1958

*Fromea amphora* Cookson & Eisenack 1958

(pl. 11, fig. 2)

1958 *Fromea amphora* Cookson & Eisenack, p. 56, pl. 5, figs. 10, 11.

Observed Dimensions: Overall 77(69)50 x 75(62)50$\mu$.
Specimens Measured — 13.
Observed Range: Valanginian to Barremian.
Previously Reported Range: Barremian to Cenomanian.

Genus *Impletosphaeridium* Morgenroth 1966

*Impletosphaeridium whitei* (Deflandre & Courteville 1939) Morgenroth 1966

(pl. 5, fig. 6)

1939 *Hystrichosphaeridium whitei* Deflandre & Courteville, p. 103, pl. 3, figs. 5, 6.
1963 *Baltisphaeridium whitei* — Downie & Sarjeant, p. 92.
1966 *Impletosphaeridium whitei* — Morgenroth, p. 37, pl. 10, fig. 1.

Observed Dimensions: Overall 60(55)39 x 58(52)33$\mu$.
Specimens Measured — 5.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Albian to Eocene.

Genus *Wallodinium* Loeblich & Loeblich 1968

*Wallodinium krutzschi* (Alberti 1961) Habib 1972

(pl. 13, fig. 3)

1961 *Diplotesta krutzschi* Alberti, p. 21, pl. 7, figs. 19—21, pl. 12, figs. 6, 7.
1972 *Wallodinium krutzschi* — Habib, p. 378, pl. 12, fig. 9, pl. 13, fig. 2.

Observed Dimensions: Archeopyle Formed — Overall 135(99)77 x 44(41)35$\mu$.
Specimens Measured — 13.
Observed Range: Berriasian to Barremian.
Previously Reported Range: Hauterivian and Barremian.

*Wallodinium luna* (Cookson & Eisenack 1960a) Lentin & Williams 1973

(pl. 15, fig. 7)

1960a *Diplotesta luna* Cookson & Eisenack, pp. 10, 11, pl. 3, fig. 21.
1973 *Wallodinium luna* — Lentin & Williams, p. 140.

Observed Dimensions: Archeopyle Formed — Overall 110(96)80 x 48(37)29$\mu$.
Specimens Measured — 10.
Observed Range: Hauterivian and Barremian.
Previously Reported Range: Barremian to Cenomanian.

## VI. A Zonation based on Species Inception and Extinction

Zone A (SPE 32 and 31) — Age: Berriasian.

The lower limit of this Zone is taken as the base of the Coprolite Bed (SPE 32), the stratigraphically lowest sample studied here. The upper limit is characterised by the highest stratigraphical record of *Adnatosphaeridium apiculatum* (Cookson & Eisenack) Lentin & Williams, although the top is much better defined by the base of Zone B.

Within the unit, one has the earliest records of *Necrobroomea micropoda* (Cookson & Eisenack) Wiggins, *Cassiculosphaeridia magna* Davey and *Cyclonephelium distinctum* Deflandre & Cookson.

Zone B (SPE 30, 29, 28, 27 and 26) — Age: Berriasian and Early Valanginian.

The lower limit of this Zone is well-defined by the first stratigraphical occurrence of several distinctive forms, including *Kleithriasphaeridium eoinodes* (Eisenack) Davey, *Kleithriasphaeridium fasciatum* (Davey & Williams) Davey, *Muderongia simplex* Alberti, *Pseudoceratium pelliferum* Gocht, *Heslertonia heslertonensis* (Neale & Sarjeant) Sarjeant and *Athigmatocysta glabra* n. gen. et sp. The upper limit is also well-defined, particularly by the highest stratigraphical occurrence of three very distinctive forms, *?Prolixosphaeridium torynum* (Cookson & Eisenack) Eisenack & Kjellström, *Endoscrinium pharo* n. sp. and *Spiniferites alatus* n. sp., the last being confined to the unit. Other important forms which appear for the first time within the unit include *Achmosphaera neptuni* (Eisenack) Davey & Williams and *Phoberocysta neocomica* (Gocht) Millioud.

This is a very distinctive and well-defined unit, not least (in a negative sense) by a complete lack of *Spiniferites ramosus* (Ehrenberg) Mantell.

Zone C (SPE 25, 24, 23, 22 and 21) — Age: Valanginian and earliest Hauterivian.

The main characteristic feature of this unit is the presence throughout of *Spiniferites ramosus* (Ehrenberg) Mantell. The lower limit of the unit is characterised by the first stratigraphical occurrence of *Spiniferites ramosus* (Ehrenberg) Mantell subsp. *primaevus* nov. (which is confined to the unit), *Oligosphaeridium complex* (White) Davey & Williams, *Trichodinium ciliatum* (Gocht) Davey and *Ctenidodinium elegantulum* Millioud. The upper limit is defined by the highest stratigraphical occurrence of *Muderongia extensiva* n. sp. and *Aprobolocysta varigranosa* n. gen. et sp., both of which are confined to the top of the unit (ranging across the Valanginian — Hauterivian boundary). Within the unit, there are the first stratigraphical occurrences of such distinctive forms as *Cribroperidinium edwardsi* (Cookson & Eisenack) Davey, *Gonyaulacysta kostromiensis* (Vozzhennikova) Sarjeant, *Polysphaeridium laminaspinosum* Davey & Williams, *Oligosphaeridium asterigium* (Gocht) Davey & Williams and *Hystrichodinium furcatum* Alberti. Also, *Kleithriasphaeridium corrugatum* Davey has its stratigraphically earliest occurrence within the unit and here becomes dominant over the shorter-processed though essentially similar *Kleithriasphaeridium fasciatum* (Davey & Williams) Davey.

Zone D (SPE 20, 19, 18, 17, 16, 15, 14, 13, 12 and 11) — Age: Hauterivian.

The lower limit of this relatively large Zone is defined by the top of Zone C and by the inception of forms including *Gonyaulacysta helicoidea* (Eisenack & Cookson) Sarjeant, *Gonyaulacysta perforobtusa* n. sp. and *Spiniferites dentatus* (Gocht) Lentin & Williams. The upper limit is defined by the last observed occurrences of *Canningia* cf. *reticulata* Cookson & Eisenack and *Aprobolocysta eilema* n. gen. et sp.

Forms apparently restricted to the unit include *Gonyaulacysta perforobtusa* n. sp., *Gonyaulacysta ordocava* n. sp., *Canningia* cf. *reticulata* Cookson & Eisenack and *Aprobolocysta eilema* n. gen. et sp. Several important and long-ranging forms have their first occurrences within the unit. These include *Protoellipsodinium spinosum* Davey & Verdier, *Cleistosphaeridium polypes* (Cookson & Eisenack) Davey, *Spiniferites ramosus* (Ehrenberg) Mantell subsp. *granosus* Davey & Williams and *Coronifera oceanica* Cookson & Eisenack.

This Zone is well-defined and possesses several characteristic features absent in lower Zones, including the presence of common *Spiniferites ramosus* (Ehrenberg) Mantell. Also present are several *Gonyaulacysta helicoidea* — *Gonyaulacysta cretacea* — types of cyst (see "Remarks" under the genus *Gonyaulacysta*), some of which are restricted within the unit.

Zone E (SPE 10, 9 and 8) — Age: Late Hauterivian.

A relatively small unit, particularly characterised at its lower limit by the inception of *Deflandrea terrula* DAVEY, this being the only *Deflandrea* encountered in the present study. The lower limit is characterised further by the stratigraphically earliest occurrence of *Systematophora schindewolfi* (ALBERTI) DOWNIE & SARJEANT.

The upper limit of the unit is defined by the last occurrence of *Gonyaulacysta confossa* n. sp., and forms which in the present work were not seen to be present above this Zone include *Spiniferites dentatus* (GOCHT) LENTIN & WILLIAMS and *Lithodinia stoveri* (MILLIOUD). Forms having their inception within the unit include *Muderongia tetracantha* (GOCHT) ALBERTI and *Necrobroomea jaegeri* (ALBERTI) WIGGINS.

SPE 7, 6, 5, 4, 3, 2, 1b and 1a — Age: Latest Hauterivian to early Middle Barremian.

The eight youngest samples studied here have not been sub-divided and are considered as part of a single unit, the upper limit of any possible Zone to which these samples may belong being almost certainly higher than SPE 1a. The lower limit is defined as the top of Zone E.

The apparently distinctive change in assemblage character between SPE 3 and SPE 2 (both Early Barremian) is probably unimportant as far as species range considerations are concerned and is probably due to lithological variation rather than any other single factor. In SPE 3, one has the highest stratigraphical record in the present study of several forms which have previously been described from later deposits. These include *Hystrichodinium pulchrum* DEFLANDRE, *Cribroperidinium edwardsi* (COOKSON & EISENACK) DAVEY, *Gardodinium trabeculosum* (GOCHT) ALBERTI and *Spiniferites ramosus* (EHRENBERG) MANTELL subsp. *multibrevis* DAVEY & WILLIAMS. This apparent break is therefore considered to be unimportant.

Within the unit, one has the first stratigraphical occurrence of ?*Canninginopsis tabulata* (DAVEY & VERDIER) and the presence as a fairly common constituent of *Tenua anaphrissa* (SARJEANT) BENEDEK in SPE 2, to which it is confined.

## V. Critical Comparisons of the present Study with those of Previous Authors

In this section, the present work is contrasted with NEALE & SARJEANT (1962), SARJEANT (1966b), DAVEY (1974), ALBERTI (1961) and MILLIOUD (1969). The emphasis is placed on those species found to have different stratigraphical ranges to those published in the above papers and on those whose stratigraphical ranges are extended in the present work.

In 1962, NEALE & SARJEANT described an assemblage from a single horizon at 99.25 metres depth in the Shell West Heslerton No. 1 borehole, which is of Hauterivian age. Several species in common with those of the present work are described, including *Gonyaulacysta cretacea* and *Cribroperidinium sepimentum* as well as more long-ranging forms such as *Pseudoceratium pelliferum* (as *Eopseudoceratium gochti*), and *Heslertonia heslertonensis* (as *Gonyaulax heslertonense*). In the present work, only three specimens of *Cribroperidinium sepimentum* were seen, confined to Zone D (in SPE 17 and SPE 14). *Gonyaulacysta cretacea* also was only seen in Zone D (SPE 18 to SPE 11). Two other species described by NEALE & SARJEANT, *Muderongia crucis* and *Systematophora complicata* were also observed in the present work. *Muderongia crucis* is seen to range from SPE 11 to SPE 4 (Late Hauterivian into Early Barremian) and *Systematophora complicata* ranges from SPE 10 through the younger samples (Late Hauterivian into at least early Middle Barremian).

The range of *Cribroperidinium sepimentum* indicated by the three specimens seen here is most probably incomplete. SARJEANT (1966b) considers this form to range into the Late Hauterivian, DAVEY (1974) considers it to range into the Middle Barremian and DAVEY & VERDIER (1974) describe it as ranging into the Aptian.

The 99.25 metre sample from the Shell West Heslerton No. 1 borehole probably belongs to either the top part of Zone D or the lower part of Zone E as described here.

SARJEANT's 1966b paper (in DAVEY, DOWNIE, SARJEANT & WILLIAMS 1966) embodies a study of five samples, ranging in age from Middle Hauterivian to Late Barremian, therefore extending the range of the NEALE & SARJEANT (1962) paper. Several of the species described in SARJEANT (1966b) are in common with those described in the present work. Particularly significant is *Muderongia crucis*. SARJEANT describes this species from both of his Hauterivian samples but from none of his Barremian material. In the present study, *Muderongia crucis* was seen in the Late Hauterivian and Early Barremian, this upper limit being confirmed in DAVEY 1974.

Several of the species described in SARJEANT 1966b appear to have unusually restricted ranges when compared with those seen in the present work. In particular, *Dingodinium alberti* was not recorded by SARJEANT below the Early Barremian, whereas in the present work it has been seen to range from the Berriasian through to the Middle Barremian. Also, *Necrobroomea longicornuta* was described by SARJEANT (as *Broomea ? longicornuta*) as occurring only in his Late Barremian sample. In the present work, it has been seen to range from the Early Hauterivian. *Kleithriasphaeridium fasciatum* (as *?Cordosphaeridium fasciatum*) was recorded by SARJEANT only from his Early Barremian sample, whereas in the present work it is recorded in abundance from SPE 30 to SPE 23 (Berriasian to Late Valanginian). This type of cyst is represented thereafter very largely by *Kleithriasphaeridium corrugatum*. There is very probably development of *K. corrugatum* from *K. fasciatum* in the Late Valanginian, *K. corrugatum* being very dominant from this level into the Early Barremian but with a small percentage of residual *K. fasciatum*. It may be significant that *Kleithriasphaeridium fasciatum* was a rare form as described in SARJEANT (1966b) and that it was not recorded at all in DAVEY (1974). It is possible that the post-Valanginian records of *K. fasciatum* are of reworked specimens.

A more detailed and comprehensive study of the Barremian Stage of the Speeton Clay is conducted in DAVEY (1974). In this paper, DAVEY describes several species in common with those of the present work. In the present work, only the seven highest samples studied are Barremian in age and five of these are taken from the Lower B division at Speeton.

In his range chart (Fig. 5) DAVEY includes several forms of which there are no European pre-Barremian records. Some of these are new species but some have been previously described. *Necrobroomea micropoda* (as *"Broomea" pellifera*) was described by DAVEY from no earlier than latest Early Barremian, whereas in the present study, it has been recorded from the Berriasian onwards. *Cassiculosphaeridia magna* is a form which was newly described in DAVEY (1974). DAVEY recorded this species only from the Early Barremian. In the present study, it is seen to be a long-ranging form and has been recorded from the Berriasian onwards. Another species newly described in DAVEY (1974) is *Kleithriasphaeridium corrugatum* and DAVEY recorded it only from the Early Barremian. As mentioned above, *Kleithriasphaeridium corrugatum* is probably developed from *Kleithriasphaeridium fasciatum* in the Late Valanginian. An important and very distinctive form, first described in DAVEY (1974), is *Discorsia nanna* (described by DAVEY as *Oligosphaeridium nannum*). DAVEY recorded this species only from the Early Barremian, but here it is seen to range from the Late Valanginian into the Early Barremian.

Any comparative discussion here of fossil ranges according to various authors would be incomplete without some reference to work on deposits other than the Speeton Clay. Two outstanding papers dealing with a similar stratigraphical range to that of the present work are ALBERTI (1961) and MILLIOUD (1969). These are discussed separately here.

ALBERTI includes in his range chart (after p. 44) several species in common with the present work. Of these, several are described with stratigraphical ranges different (usually slightly) from similar forms described here. These include *Hystrichodinium furcatum*, *Wallodinium krutzschi* (as *Diplotesta krutzschi*), *Phoberocysta neocomica* (as *Wetzeliella neocomica*), *Hystrichodinium pulchrum*, *Sirmiodinium grossi* and *Necrobroomea jaegeri* (as *Broomea jaegeri*). Of these, *Wallodinium krutzschi*, *Phoberocysta neocomica*, *Hystrichodinium pulchrum* and *Sirmiodinium grossi* are considered by ALBERTI to have their lowest stratigraphical occurence in the Early Hauterivian whereas in the present work, they are each recorded in the Berriasian and Valanginian also. *Hystrichodinium furcatum*, according to ALBERTI, ranges only throughout the Hauterivian but here is seen throughout the Early Barremian too. DAVEY (1974), also records *Hystrichodinium furcatum* from the Early Barremian.

*Necrobroomea jaegeri* was described by ALBERTI from the Late Barremian. In the present study it has been seen to range from the Late Hauterivian through the Early Barremian.

An important stratigraphical marker species is *Muderongia extensiva*. This was first described by ALBERTI and illustrated in his pl. 2, figs. 14—18. ALBERTI considered this form to be referable to the *Muderongia tetracantha* described in GOCHT (1957) (as *Pseudoceratium ? tetracanthum*). It was first pointed out in HASKELL (1970) and later in DAVEY (1974) that this form does not belong to *Muderongia tetracantha* and represents a separate species. Here, *Muderongia extensiva* is seen to have a very restricted stratigraphical range, being confined about the Valanginian—Hauterivian boundary.

MILLIOUD 1969 deals with the stratigraphical distribution of selected dinoflagellate cyst species in samples ranging in age from the Berriasian to the early part of the Aptian. In his range charts, MILLIOUD displays the ranges of several species in common with species described in the present work. Of these ranges, most compare well with those seen in the present work, but some differ from those presented here. *Cribroperidinium edwardsi* (as *Cribroperidinium orthoceras*) was described as ranging from Berriasian to Aptian, whereas in the present study, the earliest stratigraphical occurrence is uppermost Valanginian. *Kleithriasphaeridium eoinodes* (as *Cordosphaeridium eoinodes*), according to MILLIOUD, ranges from Valanginian to Aptian. Here, the observed range is Berriasian to Late Hauterivian. MILLIOUD considers both *?Dingodinium albertii* and *Ctenidodinium elegantulum* to range from Hauterivian to Late Barremian. In the present work, *Dingodinium albertii* is seen to range throughout the studied interval, a result which is not surprising when one considers that DODEKOVA (1971, pp. 6, 7) has recorded this species from the Tithonian of Bulgaria. *Ctenidodinium elegantulum* has been recorded in the present study from Valanginian to top Hauterivian. Since *Ctenidodinium elegantulum* has been recorded throughout the Barremian in both MILLIOUD (1969) and DAVEY (1974), the upper limit as recorded here is not the true stratigraphical limit of the species and is probably due to palaeo-environmental factors. *Oligosphaeridium complex* was described by MILLIOUD as ranging from Early Hauterivian to Aptian. In the present work, the earliest record of this form is in the Valanginian.

## VI. Conclusions

The majority of the samples studied here have produced large and diverse microfloral assemblages. Dinoflagellate cysts are dominant, although spores and pollen occur consistently but in low numbers. Acritarchs are rare.

The palynomorph preservation is often excellent and usually very good. The preservation is clearly related to the depositional environment and lithological nature of the Speeton Clay (i. e. usually dark clays and marls with pyrite and associated glauconite). Except in the few small, oxidised assemblages isolated from the paler and more calcareous clays, the abundance and preservation of the dinoflagellate cysts in particular would suggest slow deposition in a reducing environment.

The richness of the microfloras and the good preservation has facilitated the sub-division of that part of the Speeton Clay studied here into six palynological units. Even though many of the species recorded are long-ranging, there are a number of taxa which appear to have significant stratigraphical value. Several of these have not been previously described.

The present work is by no means an exhaustive study, having considered only thirty-three samples over a fairly long stratigraphical range. Further work will probably reveal other potentially useful forms and will add more detail to the stratigraphical distribution of the types already recognised here. The present study does, however, confirm that the Speeton Clay forms a very useful palynological reference section for the boreal Lower Cretaceous and that it can be distinctly sub-divided using the stratigraphical distribution of dinoflagellate cysts. Further work on other Early Cretaceous sections will be necessary to support the value of this zonation for correlative purposes.

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# VIII. Explanation of Plates

All figures x 750 unless otherwise stated. Slide coordinates refer to Leitz Microscope No. 516137 in the Palynology Section of the British Petroleum Company Limited, Sunbury-on-Thames, England. All holotypes are to be found in the collection of this Section.

## Plate 1

Fig. 1. *Gonyaulacysta perforobtusa* n. sp., holotype. Slide ref. SPE 14-3/1116-338.
Fig. 2. *Gonyaulacysta helicoidea* (Eisenack & Cookson 1960) Sarjeant 1966a.
Figs. 3, 4. *Gonyaulacysta diutina* n. sp.; 3 holotype, slide ref. SPE 28-2/938-220; 4 paratype x 850, focused to show the main body ornament. 4 slide ref. SPE 28-3/1115-507.
Fig. 5. *Gonyaulacysta cretacea* (Neale & Sarjeant 1962) Sarjeant 1969.
Figs. 6, 7. *Gonyaulacysta exsanguia* n. sp.; 6 holotype, slide ref. SPE 14-1/1055-315; 7 paratype x 1000, ventral focus. 7 slide ref. SPE 14-4/1120-380.
Figs. 8, 9, 12. *Gonyaulacysta fastigiata* n. sp.; 8, 12 holotype, slide ref. SPE 11-3/960-545; 9 paratype, 9 slide ref. SPE 14-2/985-534. 12 x 1000.
Figs. 10, 11. *Gonyaulacysta ordocava* n. sp. holotype, slide ref. SPE 21-D/1066-445; 10 showing overall test outline, 11 demonstrating the sutural crest perforations.

## Plate 2

Fig. 1. *Cribroperidinium sepimentum* Neale & Sarjeant 1962.
Figs. 2—4. *Gonyaulacysta confossa* n. sp.; 3, 4, holotype, slide ref. SPE 9-3/992-596. 3 focused to show the characteristic test perforation; 2 paratype, ventral focus. 2 slide ref. SPE 8-1/913-324.
Fig. 5. *Gonyaulacysta cladophora* (Deflandre 1938) Dodekova 1967, ventral focus.

## Plate 3

Figs. 1, 5. *Occisucysta evitti* (Dodekova 1969) Gitmetz 1970; 1 focused to show the large archeopyle; 5 ventral focus.
Fig. 2. *Gonyaulacysta cassidata* (Eisenack & Cookson 1960) Sarjeant 1966a.
Figs. 3, 4, 7. *Gonyaulacysta kostromiensis* (Vozzhennikova 1967) Sarjeant 1969; 3 x 1000, focused to demonstrate the apical horn tabulation.
Fig. 6. *Cribroperidinium edwardsi* (Cookson & Eisenack 1958) Davey 1969a.
Figs. 8, 9. *Occisucysta tentoria* n. sp., holotype, slide ref. SPE 21-A/1013-590; 9 x 1000, focused to show the two-plate precingular archeopyle.

## Plate 4

Fig. 1. *Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854 subsp. *ramosus* Davey & Williams 1966a.
Figs. 2, 3. *Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854 subsp. *primaevus* nov., slide ref. SPE 25-1/1117-515; 3 x 1050.
Fig. 4. *Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854 subsp. *multibrevis* Davey & Williams 1966a, x 1000.
Figs. 5—9. *Spiniferites dentatus* (Gocht 1959) Lentin & Williams 1973; 7, 8, 9 x 1050, showing the considerable variation in sutural process development.

## Plate 5

Figs. 1—3. *Avellodinium falsificum* n. gen. et sp.; 1, 2, holotype, slide ref. SPE 5-4/982-484, 2 x 1000; 3 paratype, epitract detached, ventral focus, x 1000. 3 slide ref. SPE 5-1/1095-478.
Fig. 4. *Spiniferites alatus* n. sp., holotype, slide ref. SPE 28-2/1053-440.
Fig. 5. *Spiniferites ramosus* (Ehrenberg 1838) Mantell 1854, subsp. *granosus* Davey & Williams 1966a.
Fig. 6. *Impletosphaeridium whitei* (Deflandre & Courteville 1939) Morgenroth 1966, x 1000.
Fig. 7. *Systematophora schindewolfi* (Alberti 1961) Downie & Sarjeant 1964.
Fig. 8. *Oligosphaeridium complex* (White 1842) Davey & Williams 1966b.

## Plate 6

Figs. 1—4. *Oligosphaeridium asterigium* (Gocht 1959) Davey & Williams 1969; demonstrating the range of variation of the processes 2x 475.
Fig. 5. *Oligosphaeridium pulcherrimum* (Deflandre & Cookson 1955) Davey & Williams 1966b; focused to demonstrate the fenestrate process termination.

## Plate 7

Figs. 1, 3. *Kleithriasphaeridium corrugatum* Davey 1974. 3 a detail clearly showing the precingular archeopyle.
Fig. 2. *Hystrichodinium furcatum* Alberti 1961.
Figs. 4, 9. *Kleithriasphaeridium fasciatum* (Davey & Williams 1966b) Davey 1974.

Figs. 5, 6. *Heliodinium voigti* Alberti 1961 emend. Sarjeant 1966a. 5 has completely reduced spines except at the antapex. 6 has a little more spine development than 5.
Fig. 7. *Kleithriasphaeridium eoinodes* (Eisenack 1958) Davey 1974.
Fig. 8. *Systematophora complicata* Neale & Sarjeant 1962.

## Plate 8

Figs. 1, 2. *Cyclonephelium distinctum* Deflandre & Cookson 1955. 1 with apical portion displaced, 2 with apical portion completely detached.
Figs. 3, 4. ? *Canninginopsis tabulata* (Davey & Verdier 1974) n. comb. 3 shows the overall outline of the test, 4 dorsal focus.
Fig. 5. *Lithodinia pertusa* n. sp., holotype. Slide ref. SPE 20-A/995-538.
Fig. 6. *Canningia* cf. *reticulata* Cookson & Eisenack 1960b.

## Plate 9

Fig. 1. *Canningia* cf. *reticulata* Cookson & Eisenack 1960b.
Fig. 2. *Nematosphaeropsis scala* n. sp., holotype. Slide ref. SPE 22-4/1000-398.
Fig. 3. *Parvocavatus spinosus* n. sp., holotype, stained specimen. Slide ref. SPE 32-α/1100-290, x 1000.
Fig. 4. *Dingodinium albertii* Sarjeant 1966b. Specimen showing the intercalary split, smooth apical portion of the inner body and sulcal hole.
Fig. 5. *Endoscrinium pharo* n. sp., holotype. Slide ref. SPE 26-1/984-257.
Fig. 6. *Chlamydophorella nyei* Cookson & Eisenack 1958. x 1000.
Figs. 7, 8. *Ctenidodinium elegantulum* Millioud 1969.

## Plate 10

Fig. 1. *Adnatosphaeridium apiculatum* (Cookson & Eisenack 1960b) Lentin & Williams 1973.
Fig. 2. *Psaligonyaulax apatela* (Cookson & Eisenack 1960b) Sarjeant 1969.
Figs. 3, 4. *Protoellipsodinium spinosum* Davey & Verdier 1971. 3 demonstrates the precingular archeopyle.
Fig. 5. *Endoscrinium campanula* (Gocht 1959) Vozzhennikova 1967.
Fig. 6. ? *Prolixosphaeridium torynum* (Cookson & Eisenack 1960b) Eisenack & Kjellstrom 1971.
Fig. 7. *Gardodinium trabeculosum* (Gocht 1959) Alberti 1961.
Fig. 8. *Discorsia nanna* (Davey 1974) n. comb., x 1000.
Fig. 9. *Coronifera oceanica* Cookson & Eisenack 1958.
Fig. 10. *Callaiosphaeridium asymmetricum* (Deflandre & Courteville 1939) Davey & Williams 1966b.

## Plate 11

Figs. 1, 6. *Athigmatocysta glabra* n. gen. et sp., holotype. Slide ref. SPE 18-A/992-437.
Fig. 2. *Fromea amphora* Cookson & Eisenack 1958.
Fig. 3. *Cleistosphaeridium polypes* (Cookson & Eisenack 1962) Davey 1969a.
Fig. 4. *Polysphaeridium laminaspinosum* Davey & Williams 1966b.
Fig. 5. *Systematophora vetuscula* (Davey 1974) n. comb.
Fig. 7. *Heslertonia heslertonensis* (Neale & Sarjeant 1962) Sarjeant 1966a.
Fig. 8. *Cassiculosphaeridia magna* Davey 1974. Specimen demonstrating the apical archeopyle.

## Plate 12

Figs. 1, 2, 4, 5. *Speetonia delicatula* n. gen. et sp., 4 holotype, slide ref. SPE 25-4/1044-296, 1, 2 and 5 paratypes, 2 demonstrating the granular ornament sometimes present in the species and the two-plate precingular archeopyle. 2 slide ref. SPE 25-1/944-418. 1 slide ref. SPE 26-2/1092-455. 5 slide ref. SPE 26-2/963-423.
Figs. 3, 6—9. *Sirmiodinium grossi* Alberti 1961 emend. Warren 1973. Four specimens demonstrating the morphological variation within this species as seen in the present work. 8 detail of 7, focused to show the ventral tabulation x 1000. 3, 6—8, stained specimens.

## Plate 13

Fig. 1. *Trichodinium ciliatum* (Gocht 1959) Davey 1974.
Fig. 2. *Lithodinia stoveri* (Millioud 1969) n. comb.
Fig. 3. *Wallodinium krutzschi* (Alberti 1961) Habib 1972.
Fig. 4. *Achomosphaera neptuni* (Eisenack 1958) Davey & Williams 1966a.
Fig. 5. *Heliodinium voigti* Alberti 1961 emend. Sarjeant 1966a.

Figs. 6, 8. *Necrobroomea micropoda* (Eisenack & Cookson 1960) Wiggins 1975.
Fig. 7. *Kleithriasphaeridium simplicispinum* (Davey & Williams 1966b) Davey 1974.
Fig. 9. *Hystrichodinium pulchrum* Deflandre 1935.

## Plate 14

Figs. 1—3. *Pareodinia dasyforma* Wiggins 1975. 2 detail of 1 demonstrating the intercalary archeopyle. 2 x 1100.
Figs. 4, 5, 8. *Aprobolocysta eilema* n. gen. et sp. 4, 5 holotype; 4 demonstrates the overall shape of the test, 5 focused to show the cingular periphragm fold, 8 paratype, archeopyle formed. 4,5 slide ref. SPE 11-3/984-386. 8 slide ref. SPE 11-3/1098-545. 4, 5, 8 x 1000.
Figs. 6, 7. *Aprobolocysta varigranosa* n. gen. et sp. 6 holotype, slide ref. SPE 21-B/1007-550. 7 paratype, archeopyle formed, slide ref. SPE 21-B/906-568. 6, 7 x 1000.
Fig. 9. *Muderongia simplex* Alberti 1961.
Fig. 10. *Phoberocysta neocomica* (Gocht 1957) Millioud 1967.

## Plate 15

Fig. 1. *Pseudoceratium pelliferum* Gocht 1957. Specimen showing well-defined tabulation.
Fig. 2. *Necrobroomea longicornuta* (Alberti 1961) Wiggins 1975. Operculum detached.
Fig. 3. *Necrobroomea jaegeri* (Alberti 1961) Wiggins 1975.
Fig. 4. *Deflandrea terrula* Davey 1974.
Fig. 5. *Muderongia tetracantha* (Gocht 1957) Alberti 1961. x 450.
Fig. 6. *Muderongia staurota* Sarjeant 1966b. x 420.
Fig. 7. *Wallodinium luna* (Cookson & Eisenack 1960a) Lentin & Williams 1973.
Fig. 8. *Muderongia crucis* Neale & Sarjeant 1962. x 500.
Fig. 9. *Tenua anaphrissa* (Sarjeant 1966b) Benedek 1972. x 420.
Fig. 10. *Muderongia extensiva* n. sp., holotype. Slide ref. SPE 22-D/1088-525. x 420.


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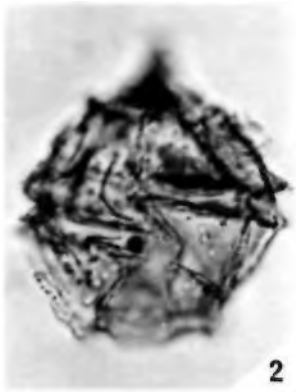
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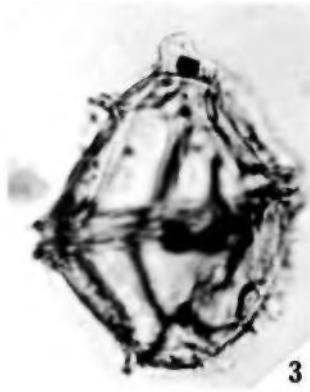
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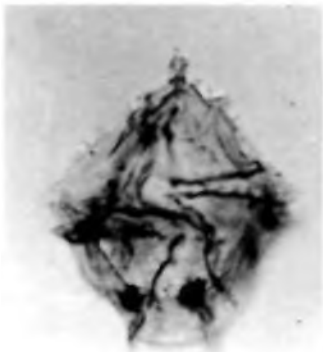
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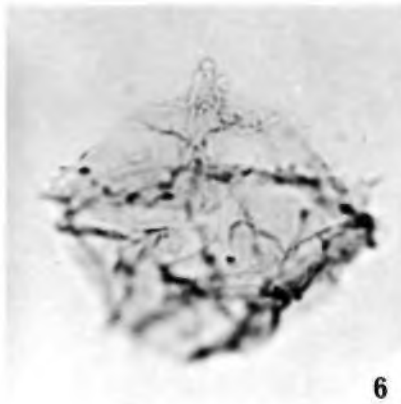
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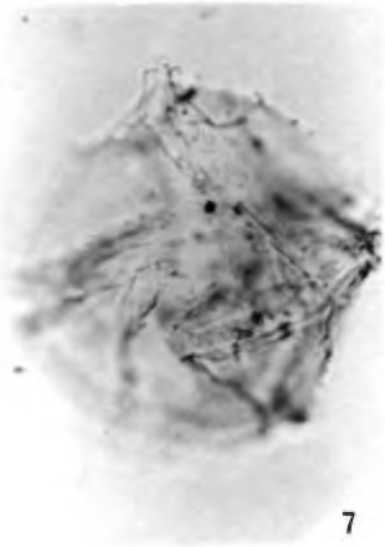
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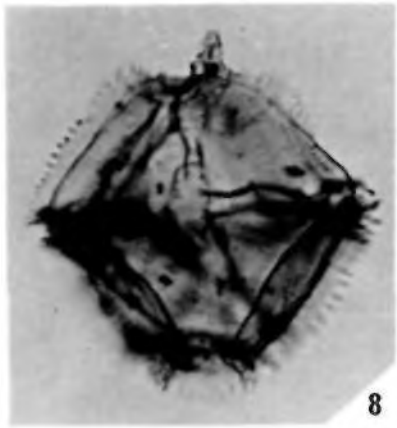
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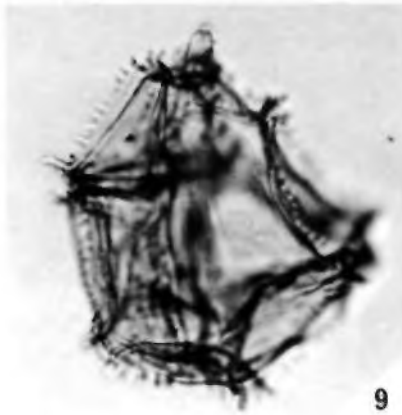
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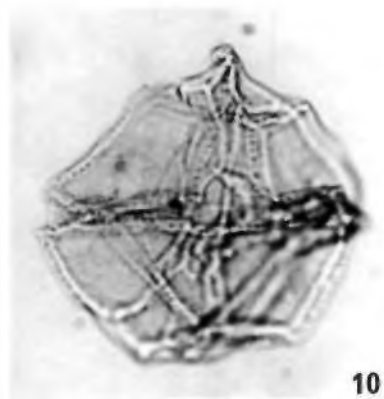
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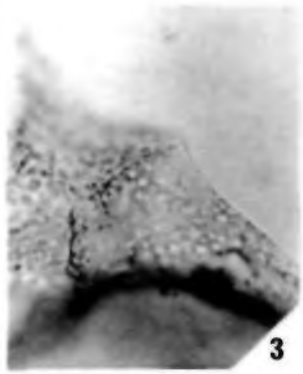
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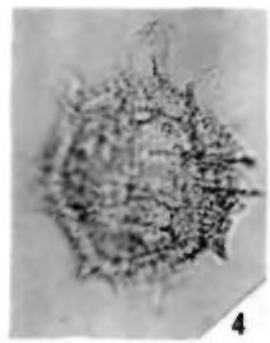
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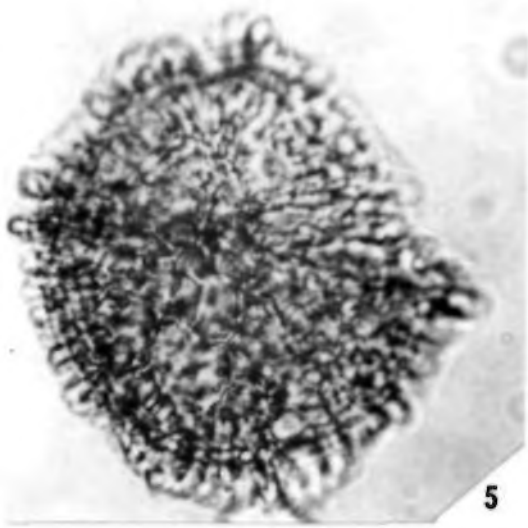
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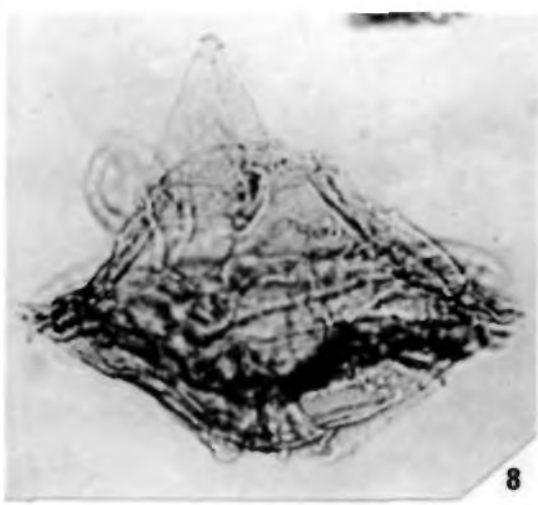
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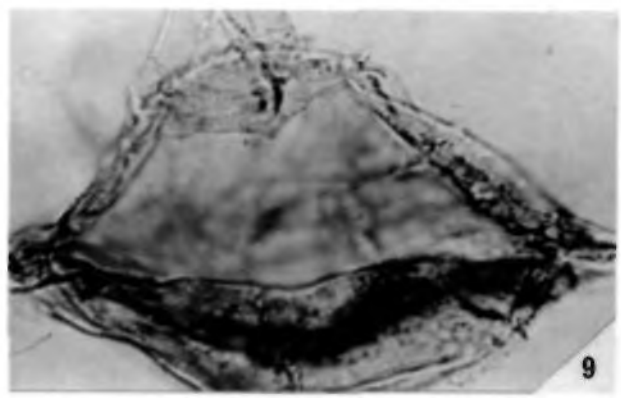
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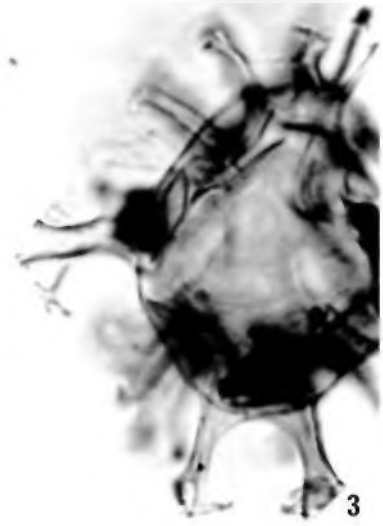
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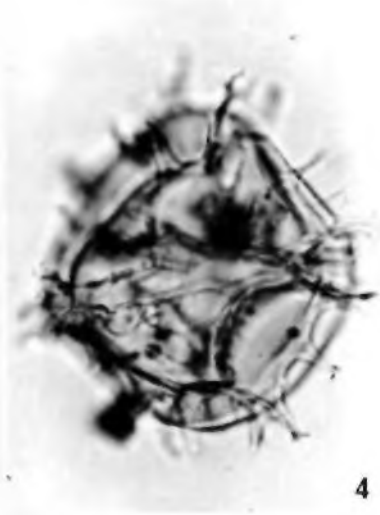
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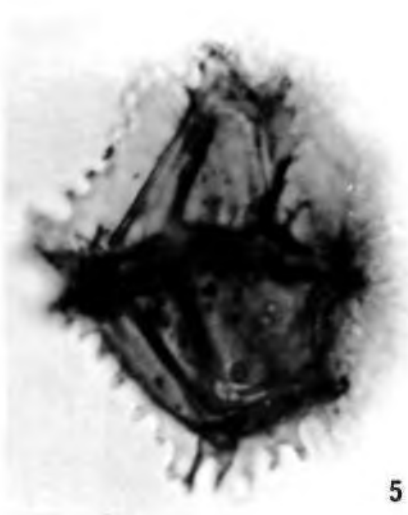
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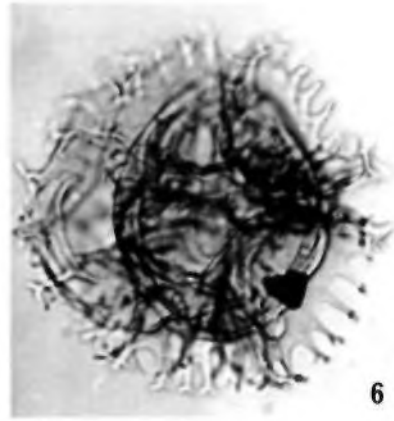
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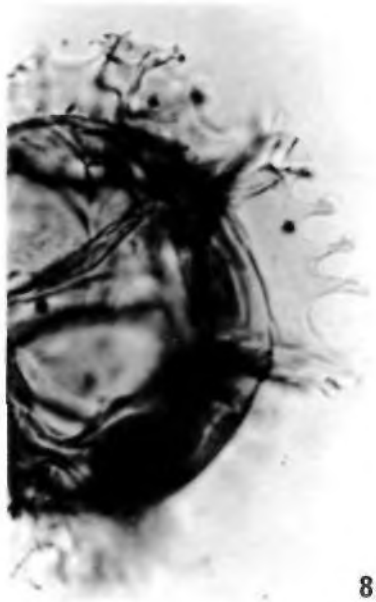
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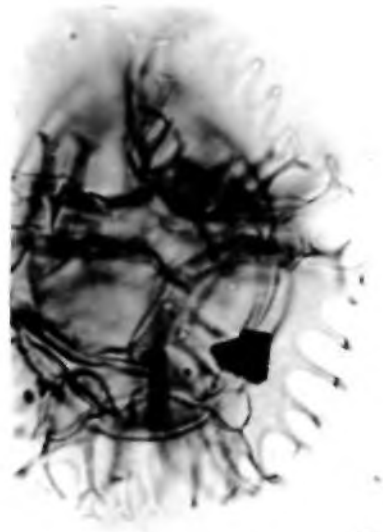
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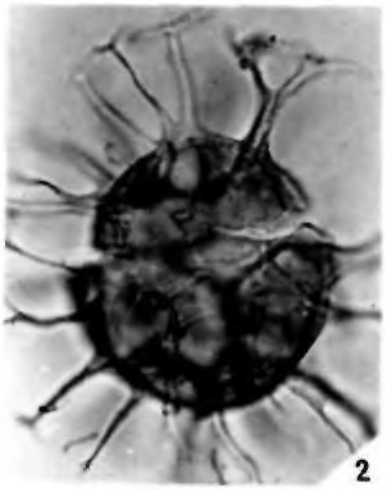
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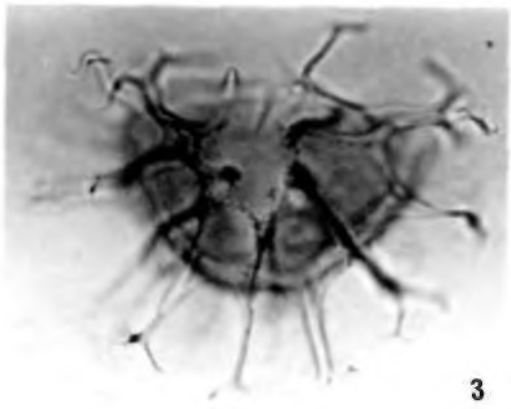
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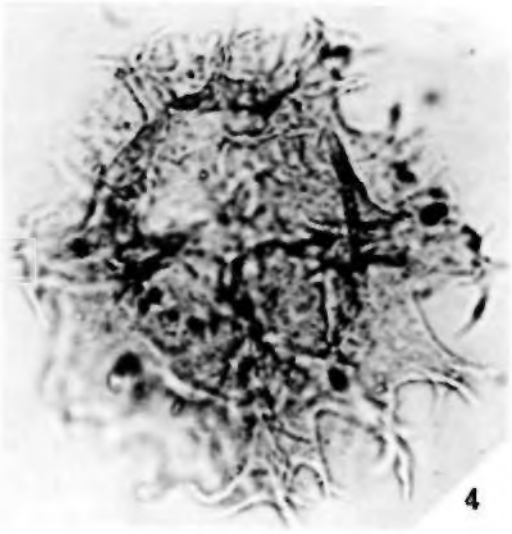
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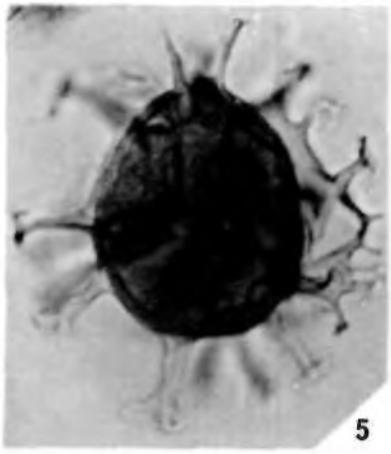
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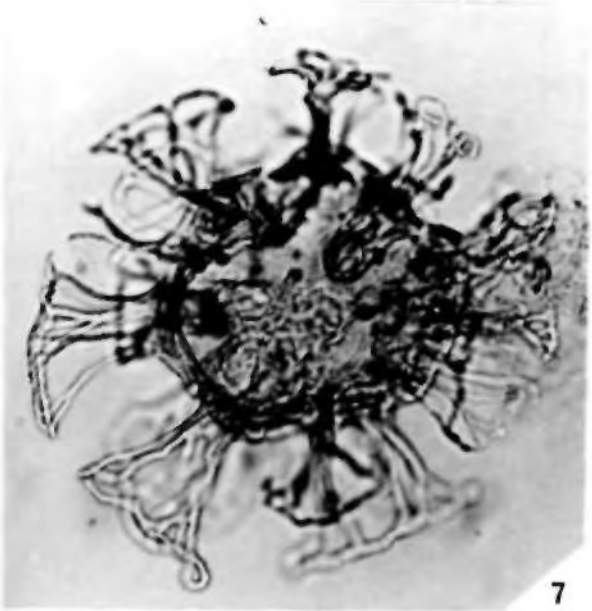
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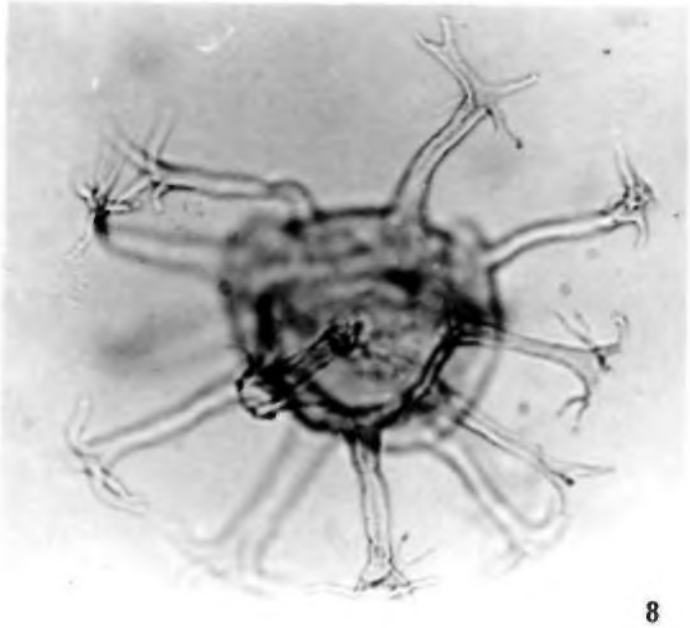
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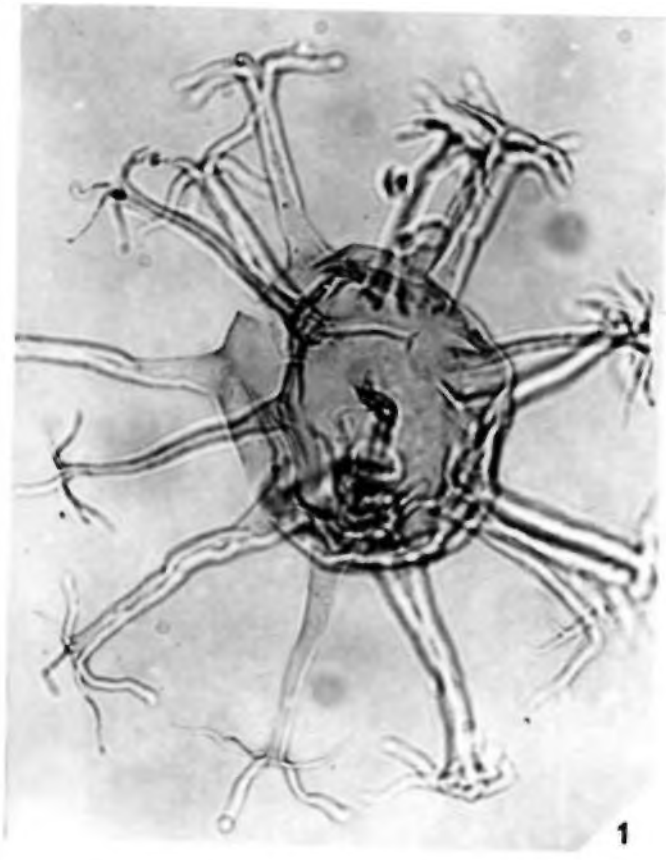
Stanley Duxbury: A Palynostratigraphy of the Berriasian to Barremian of the Speeton Clay.



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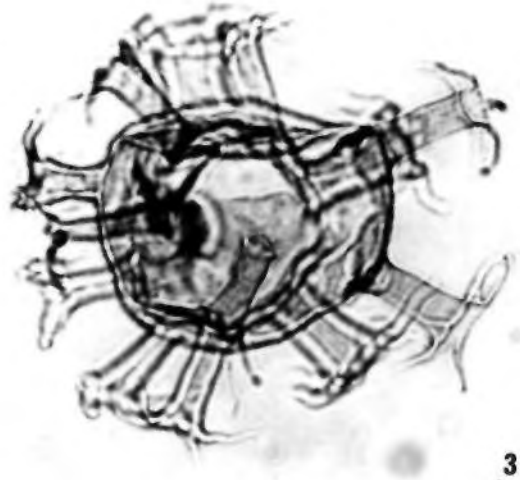

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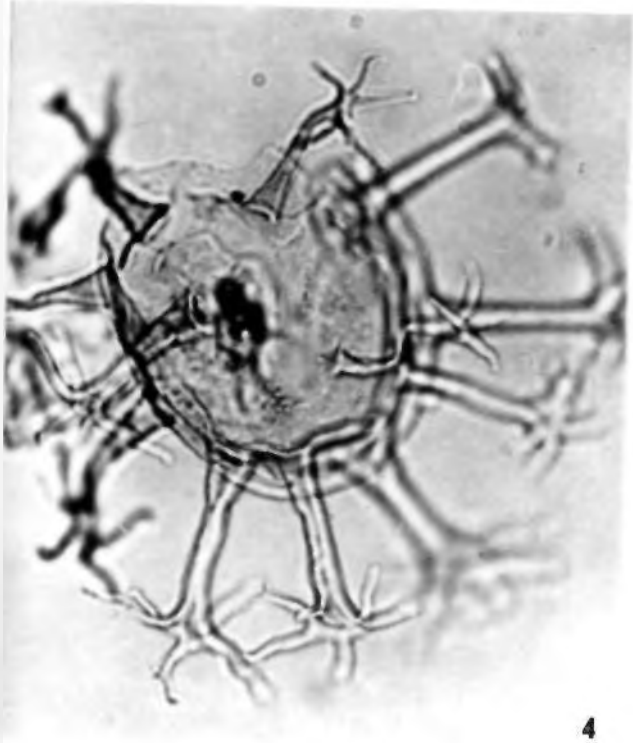

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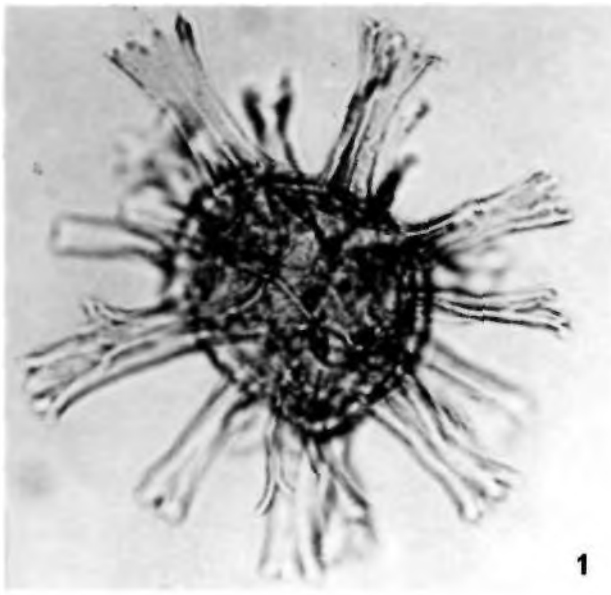
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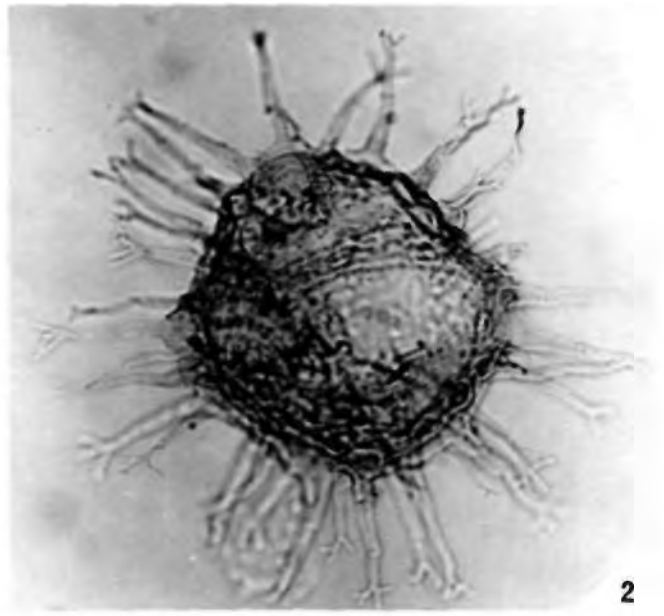
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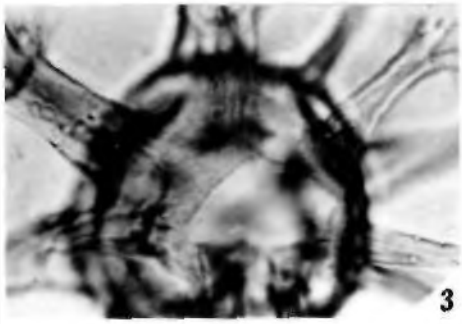
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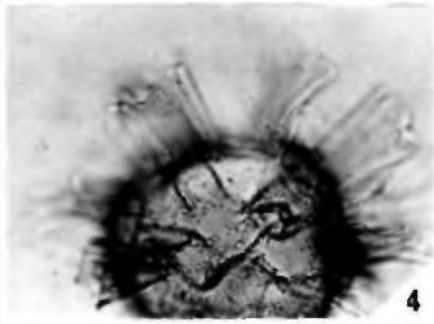
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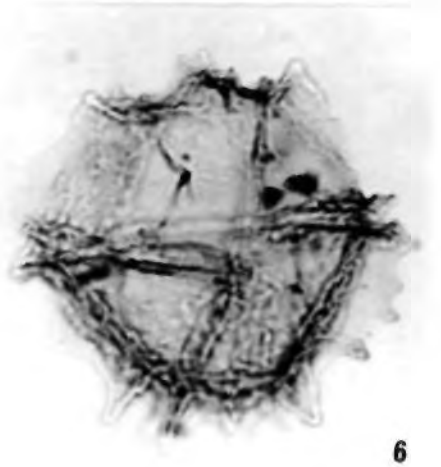
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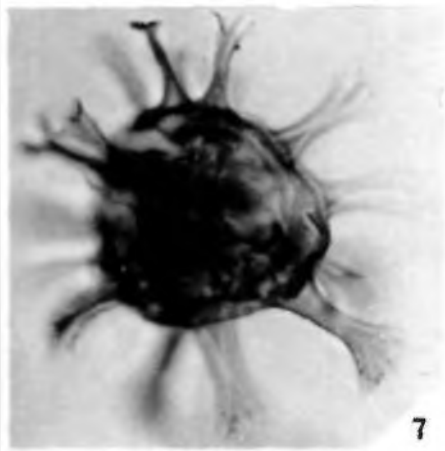
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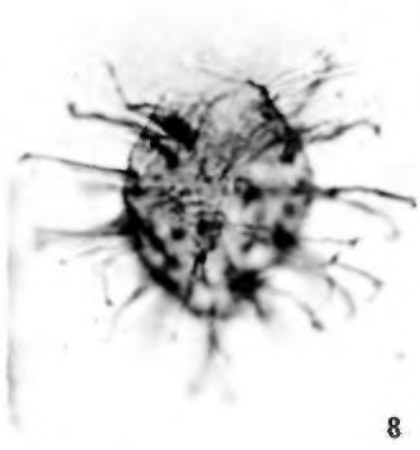
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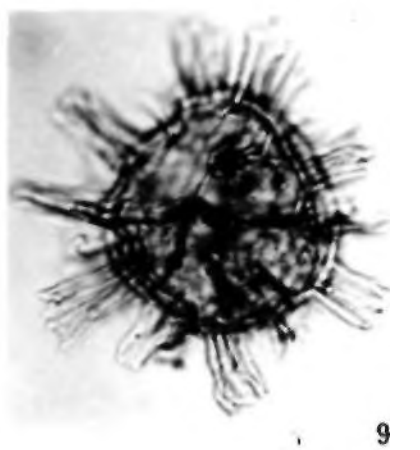
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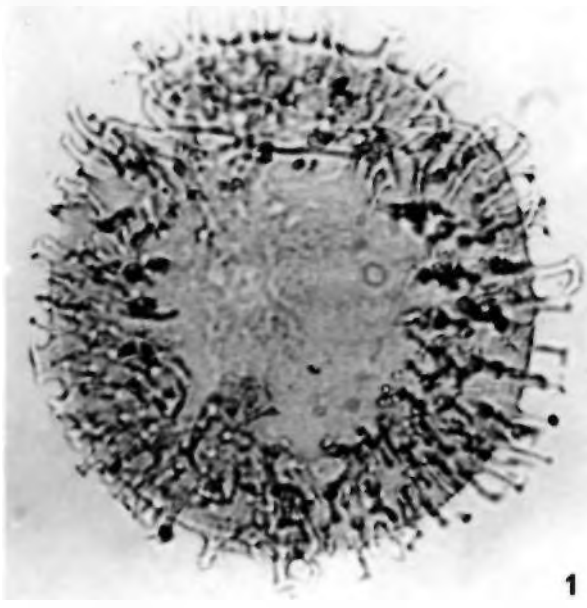
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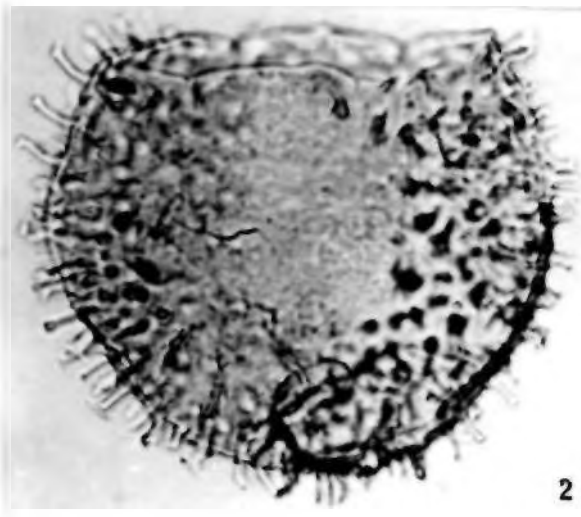
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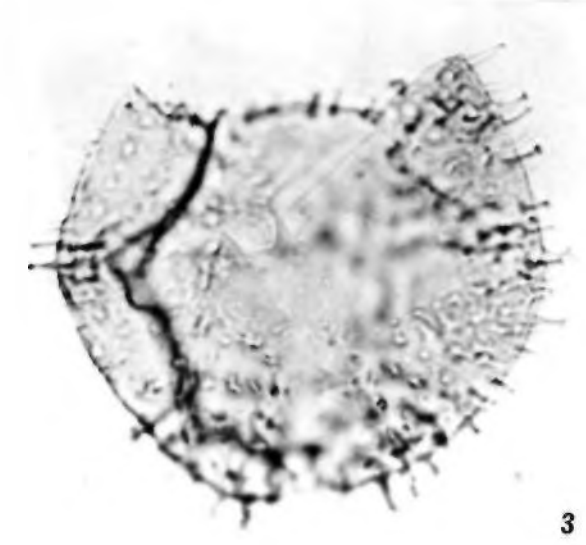
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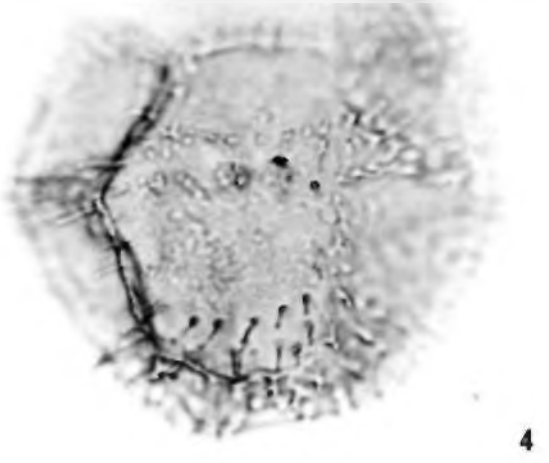
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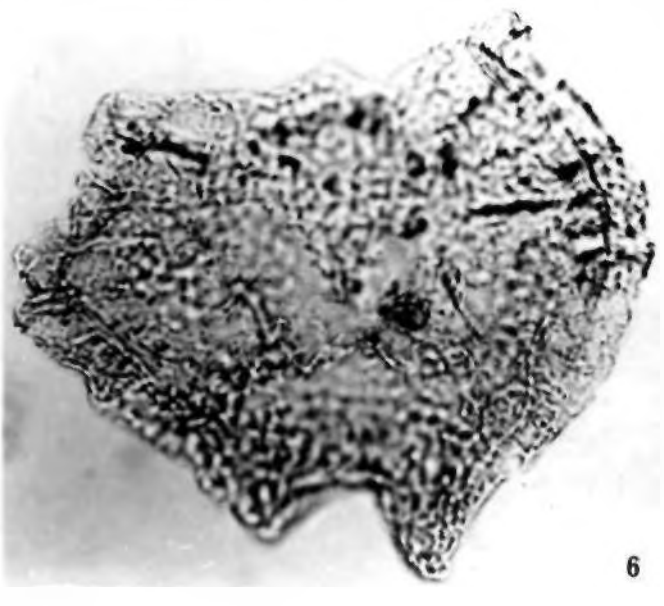
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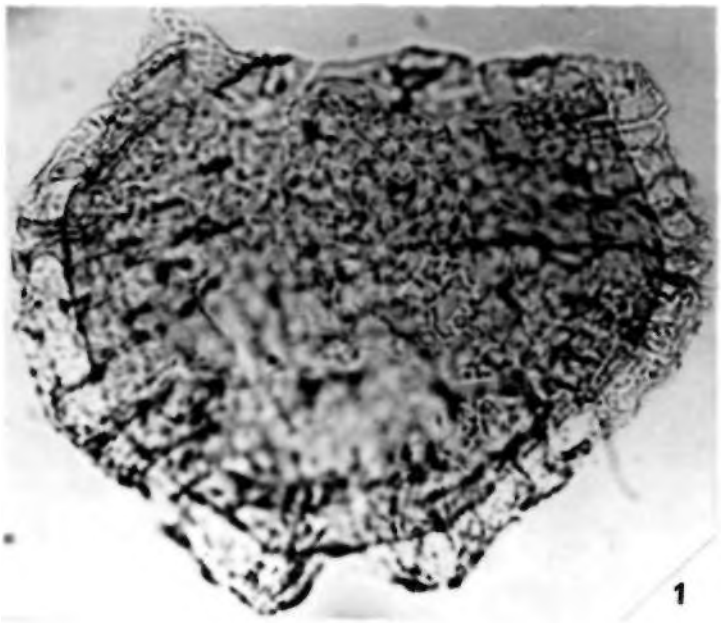
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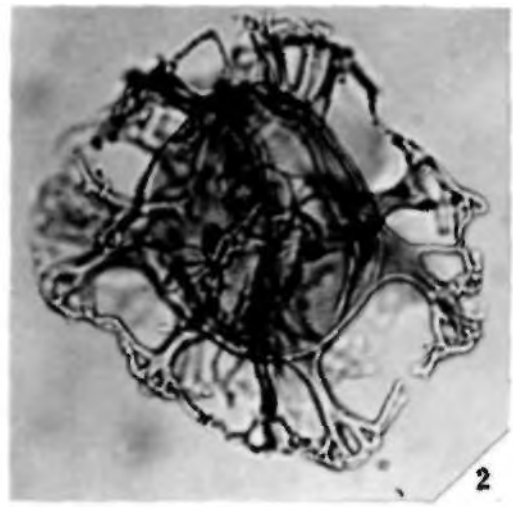
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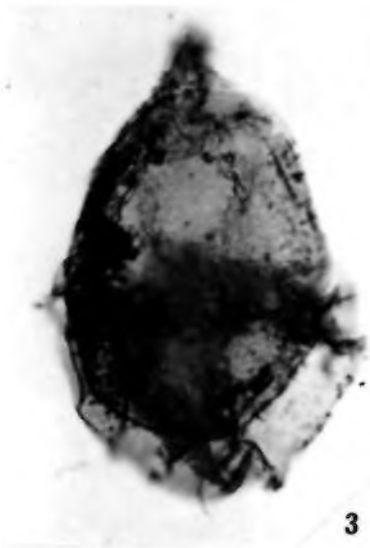
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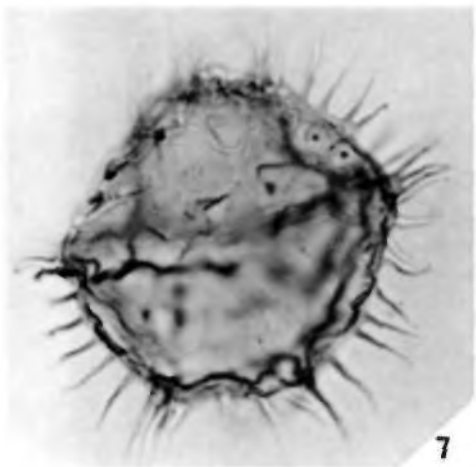
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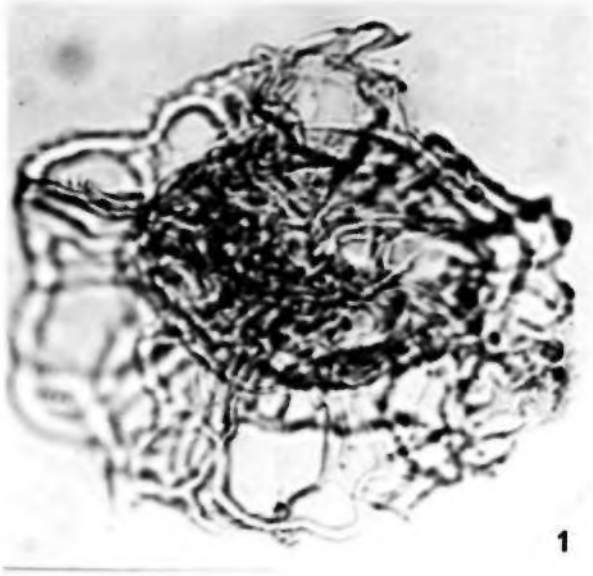
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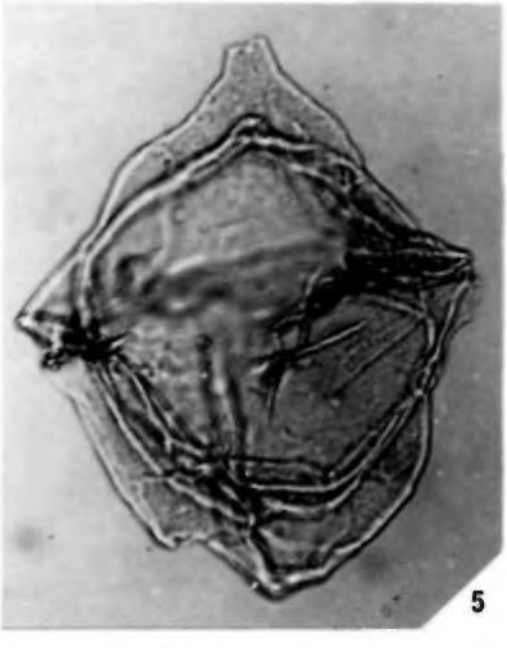
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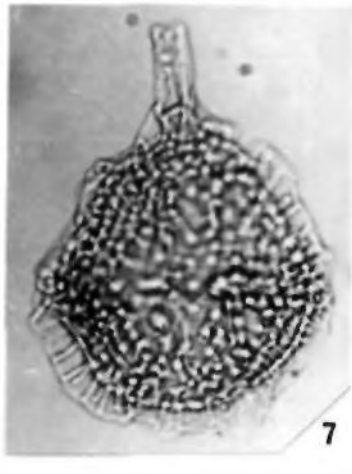
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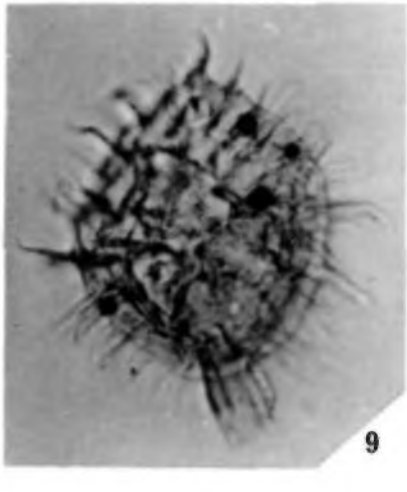
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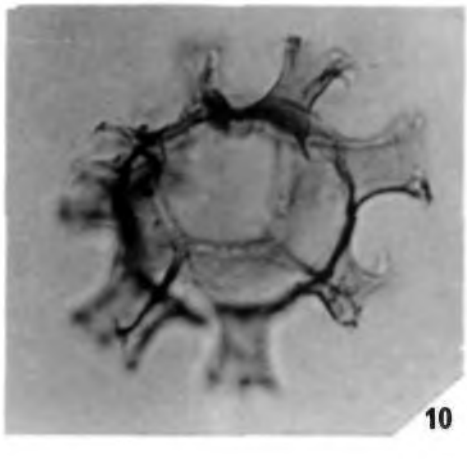
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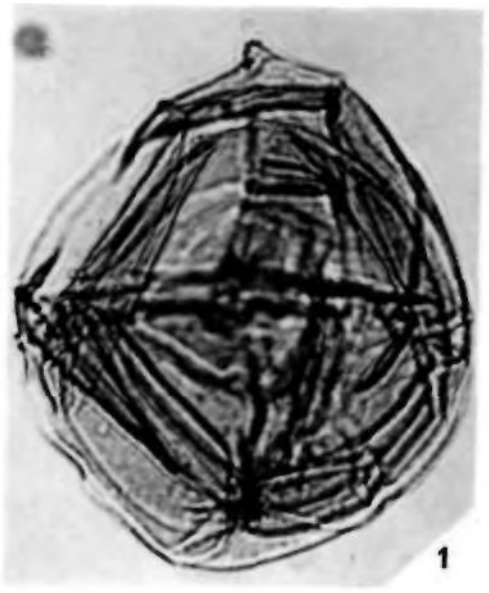
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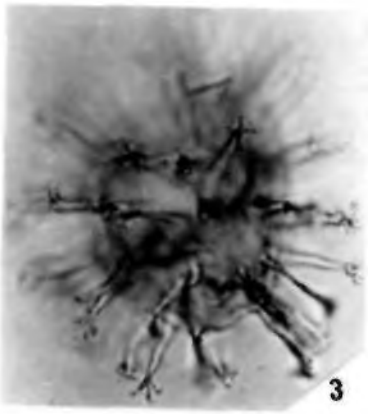
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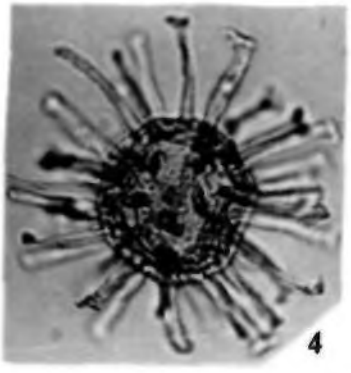
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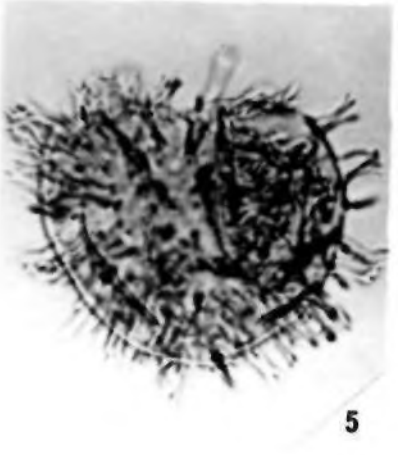
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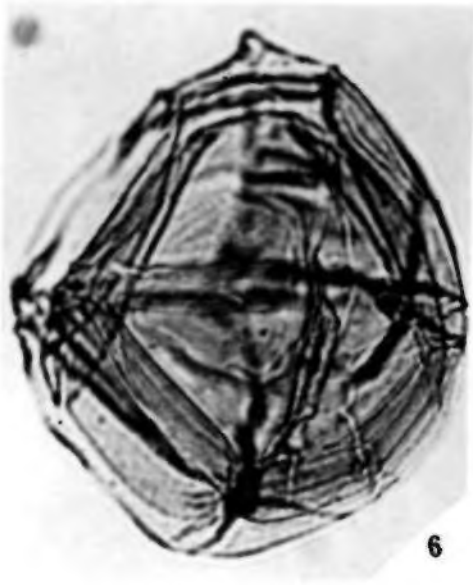
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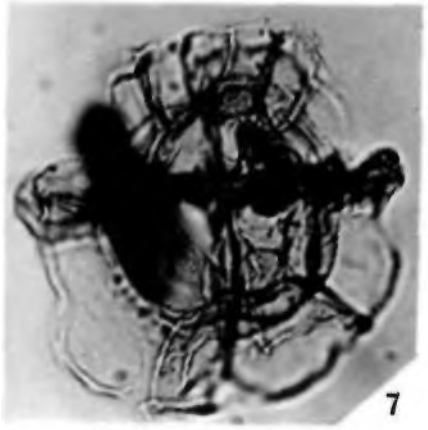
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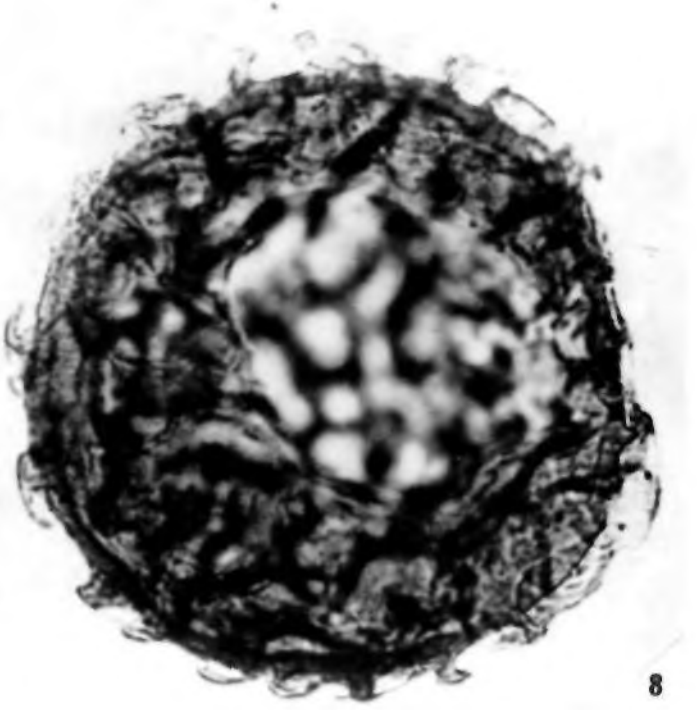
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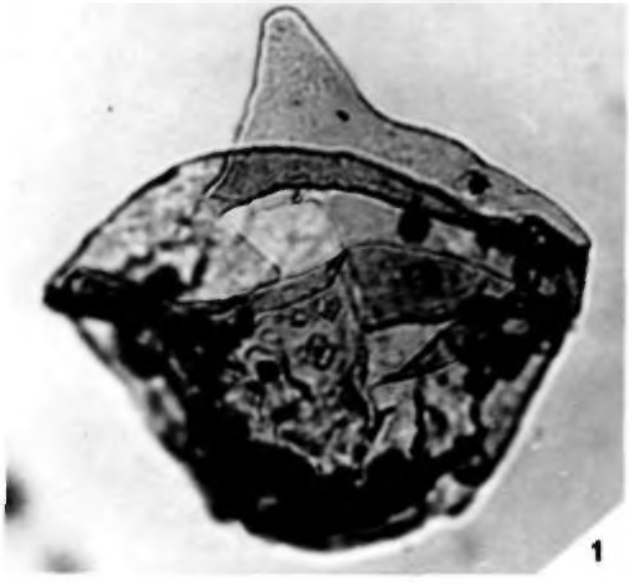
Stanley Duxbury: A Palynostratigraphy of the Berriasian to Barremian of the Speeton Clay.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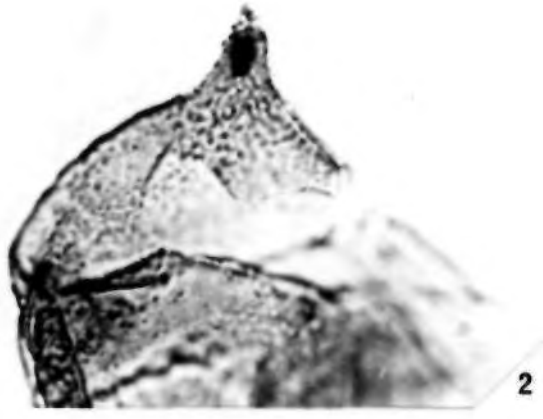
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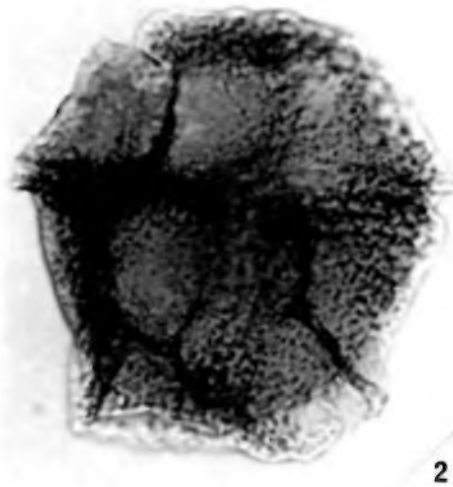
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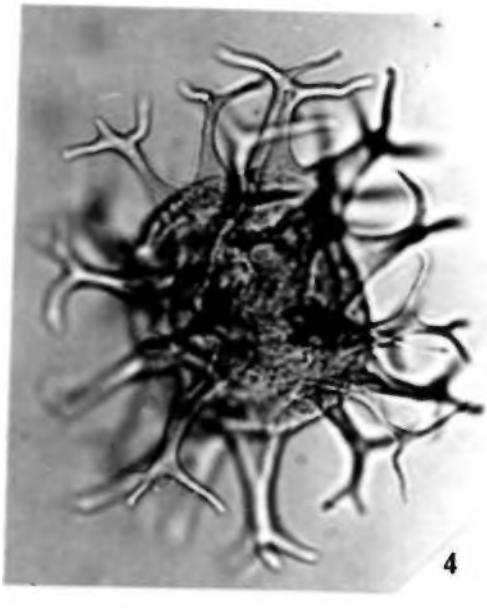
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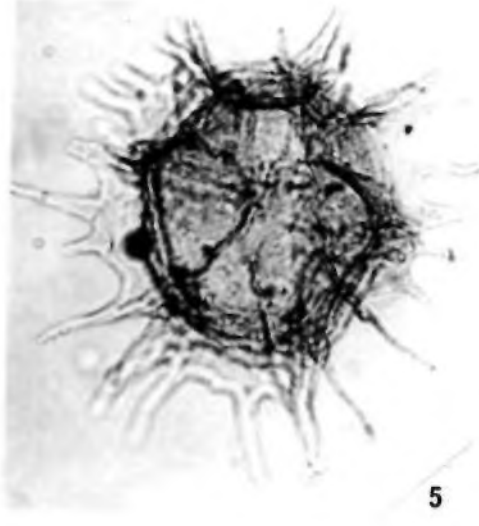
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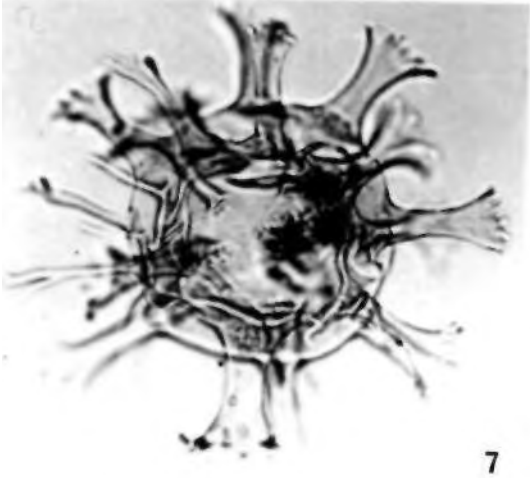
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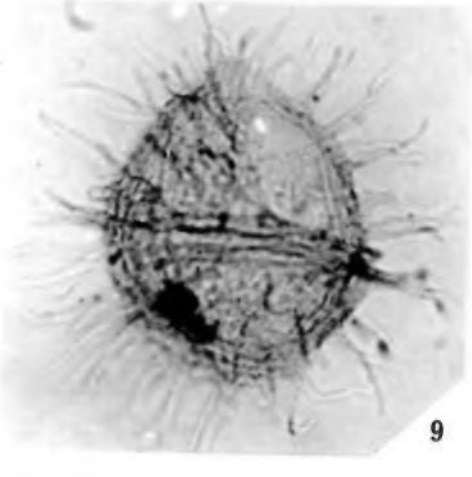
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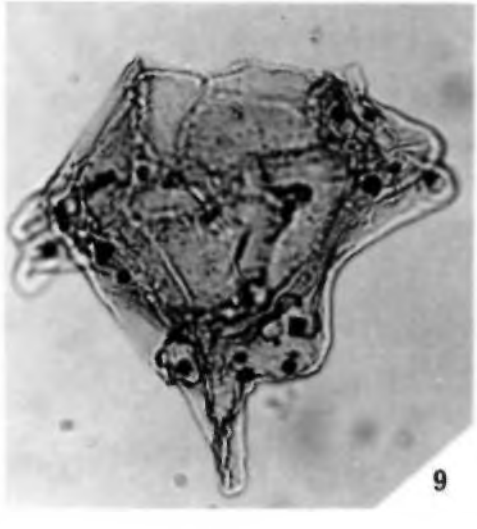
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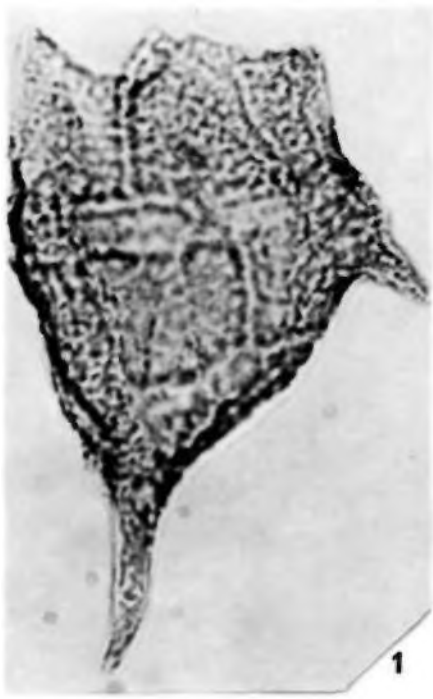
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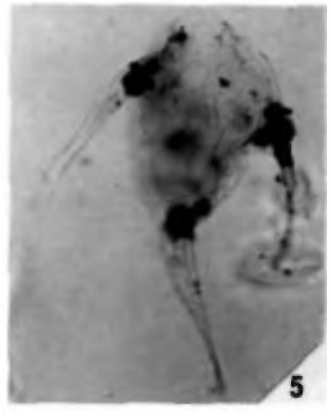
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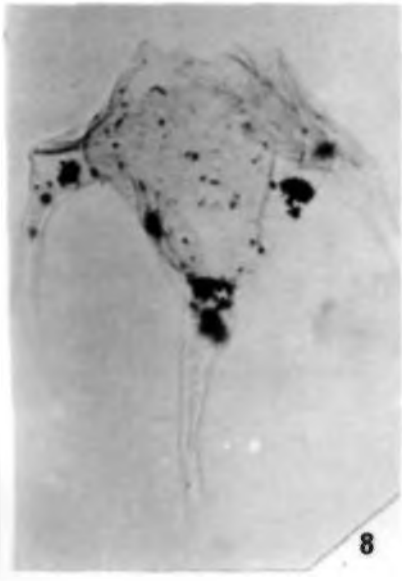
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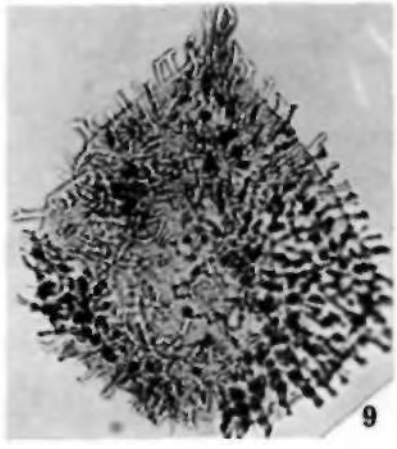
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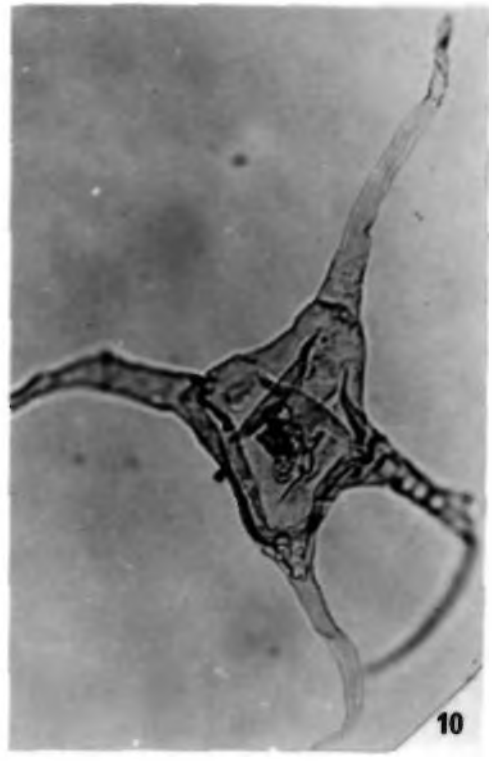
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